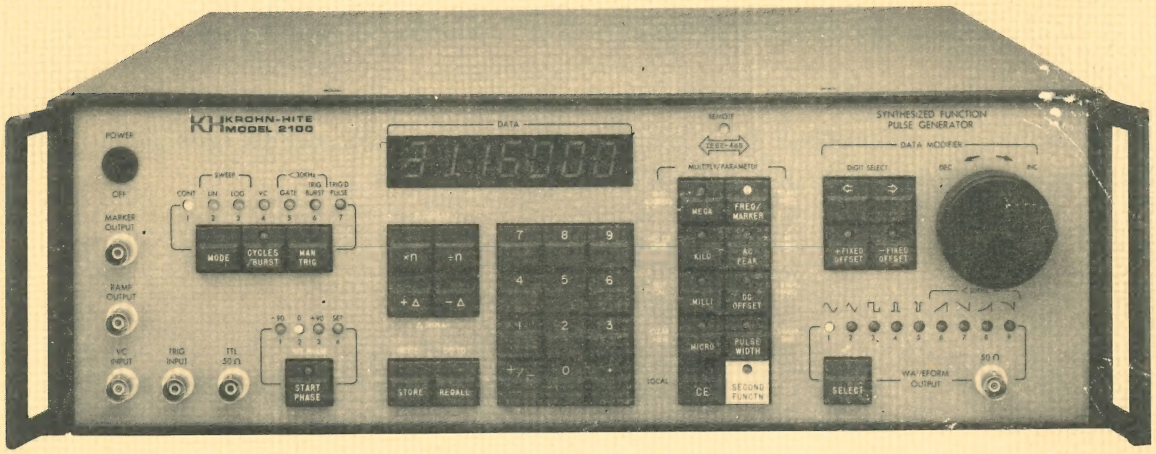
KROHN-HITE

MODEL 2100A

OPERATING and MAINTENANCE MANUAL



.01Hz to 31.16MHz

PROGRAMMABLE

FUNCTION/PULSE GENERATOR

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0.01Hz to 31.16MHz

SYNTHESIZED FUNCTION/PULSE GENERATOR

MODEL 2100A

Serial No. _____

OPERATING AND MAINTENANCE MANUAL

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TABLE OF CONTENTS

SECTION		PAGE
1.0	General Description	1-1
	1.1 Introduction	1-1
	1.2 Specifications	1-2
	1.3 Input Connectors	1-5
	1.4 Output Connectors	1-5
	1.5 Salient Features	1-6
	1.6 GPIB Programming	1-7
	1.7 General	1-7
2.0	Operation	2-1
	2.1 Introduction	2-1
	2.2 Power Requirements	2-1
	2.3 Turn-On Procedure	2-1
	2.4 Self-Test	2-2
	2.5 Front Panel	2-3
	2.5.1 Mode, Cycles/Burst, and Man Trig keys	2-3
	2.5.2 Start Phase key	2-4
	2.5.3 Data Display and Data, Xn, ÷n, +△, -△ keys	2-5
	2.5.4 Store and Recall keys	2-6
	2.5.5 Multiply/Parameter keys	2-8
	2.5.5.1 Second Functions of Multiply/Parameter keys	2-9
	2.5.6 Digit Select keys and Data Modifier Knob	2-11
	2.5.7 Fixed Offset keys	2-12
	2.5.7.1 Second Function of the + Fixed Offset Key	2-12
	2.5.8 Select key	2-13
	2.5.8.1 Second Function of the Select key	2-13
	2.5.9 LED Indicators	2-13
	2.5.10 Connectors	2-13
	2.6 Rear Panel	2-14
	2.6.1 Connectors	2-14
	2.5.2 Optional Rear BNC's	2-15
	2.6.3 Power	2-15
	2.6.4 Switches	2-15
	2.7 Primary Keyboard Operation	2-16
	2.7.1 Examples of Keyboard Commands	2-16
	2.7.2 Sweep Modes	2-17
	2.7.3 Frequency Marker	2-18
	2.7.4 VC Mode (External Frequency Control)	2-18
	2.7.5 Gate Mode	2-19
	2.7.6 Trigger Burst Mode	2-19
	2.7.7 Trigger Pulse Mode	2-19
	2.8 Presets	2-20
	2.9 Cold Start	2-20
	2.10 Entering and Displaying the Serial Number	2-21
	2.11 Displaying the Sofware Version	2-21

TABLE OF CONTENTS (cont)

SECTION		PAGE
3.0	IEEE-488 STD (GPIB) Programming	3-1
3.1	Introduction	3-1
3.2	Preliminary Programming Information	3-1
3.2.1	GPIB Primary Bus Address and ASCII Line Termination Codes	3-1
3.2.2	IEEE-488 Bus Interface Programming Connector	3-2
3.3	ASCII Data Commands	3-2
3.3.1	Format	3-2
3.3.2	Types of Data Commands	3-2
3.3.3	Table of ASCII Data Commands	3-3
3.4	IEEE-488 Standards Commands	3-6
3.4.1	Multi-Line Messages	3-6
3.4.2	Polling Commands	3-7
3.4.3	Uniline Messages	3-10
3.5	Talker Format	3-10
3.5.1	Parameter Information	3-10
3.5.2	Numeric Format	3-11
3.5.3	Parameter String Format	3-11
3.5.4	Error Conditions and Advisory Messages	3-11
3.5.5	Status	3-12
4.0	Incoming Acceptance and Routine Performance Tests	4-1
4.1	Introduction	4-1
4.2	Equipment Required	4-1
4.3	Performance Tests	4-1
4.3.1	Frequency Accuracy Check	4-2
4.3.2	Distortion Check	4-2
4.3.3	Amplitude Calibration Check	4-2
4.3.4	DC Offset Check	4-3
4.3.5	Squarewave Rise Time Check	4-3
4.3.6	Spectrum Analyzer Check	4-4
5.0	Circuit Description	5-1
5.1	Introduction	5-1
5.2	Overall System Description	5-1
5.3	High Frequency Waveform Synthesizer	5-2
5.4	Main Generator	5-3
5.5	ROM Waveform Synthesizer	5-5
5.6	Trig/Gate Control	5-6
5.7	Pulse Generator	5-8
5.8	Square and Pulse Driver	5-9
5.9	Main Output	5-9
5.10	Power Supply	5-10
5.11	Microprocessor	5-11
6.0	Maintenance	6-1
6.1	Introduction	1-1
6.2	Maintenance Procedure	6-1

TABLE OF CONTENTS (cont)

SECTION PAGE

6.2.1 Power Supply. 6-2
6.2.2 Front Panel Board 6-3
6.2.3 Microprocessor (MPU) Board. 6-3
6.2.4 Phase Lock Loop Board. 6-3
6.2.5 Main Generator Board 6-4
6.2.6 ROM Synthesizer Board. 6-5
6.2.7 Mian Output Board. 6-7

7.0 Calibration. 7-1
7.1 Introduction. 7-1
7.2 Equipment Required. 7-1
7.3 Test Procedure. 7-2
7.3.1 Power Supply (PC2100-7). 7-2
7.3.2 PLL Control Voltage Adjustment 7-2
7.3.3 Phase Detector Balance Null (PC2100-2) 7-2
7.3.4 Squarewave Level Adjust (PC2100-1) 7-2
7.3.5 TP28 DC Level Adjust (PC2100-1). 7-3
7.3.6 Frequency Control Voltage Adjust (PC2100-1). 7-3
7.3.7 Distortion Adjust (PC2100-1) 7-3
7.3.8 Sinewave DC Level and Amplitude Adjust (PC2100-1). 7-3
7.3.9 ROM SYNTHESIZER AMPLITUDE MATCH (On PC2100-5). 7-4
7.3.10 DC Level Adjust (PC2100-6) 7-4
7.3.11 33kHz SSinewave DC Level Adjust. 7-4
7.3.12 33kHz Sine Amplitude Adjust (On PC2100-6). 7-5
7.3.13 Fixed Offset Adjust (On PC2100-6). 7-5
7.3.14 Low Frequency Amplitude Adjust 7-5
7.3.15 Low Frequency Sine, Triangle DC Level Adjust 7-5
7.3 16 Squarewave Amplitude Adjust (PC2100-5) 7-5
7.3.17 Squarewave DC Level Adjust (PC2100-5). 7-5
7.3 18 DC Offset Adjust (On PC2100-6) 7-5
7.3.19 SQUAREWAVE CORNER ADJUST AND RISE TIME CHECK (On PC2100-6) 7-6
7.3.20 Trig Input Level Adjust (PC2100-5) 7-6
7.3.21 Pulse Generator Calibration.. 7-6
7.3.22 High Frequency Sine and Triangle Response. 7-7
7.3.23 Frequency Accuracy Adjust. 7-7

8.0 Parts List 8-1
8.1 Ordering Information. 8-1
8.2 Ordering Unlisted Parts 8-1

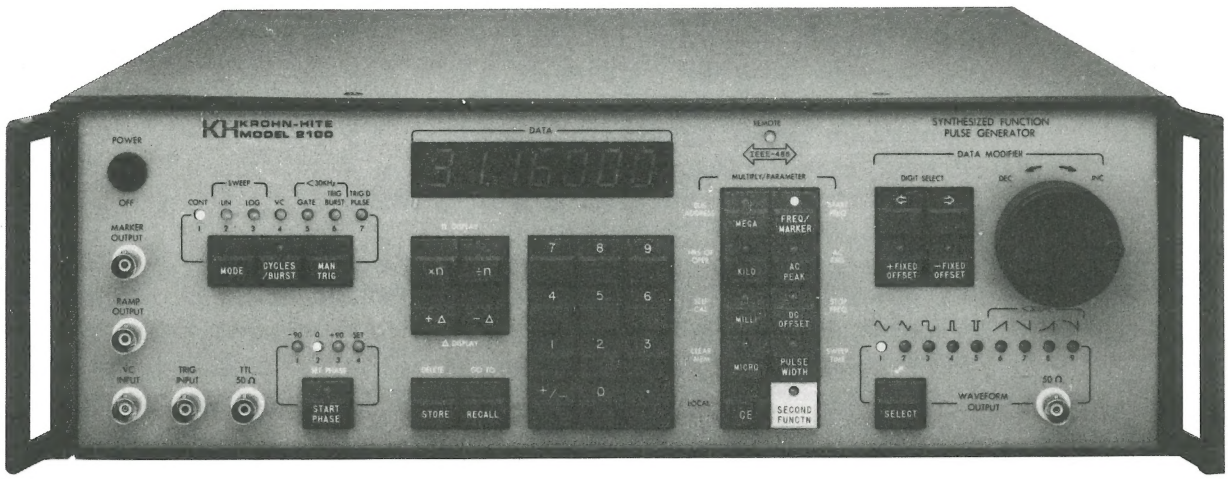


Figure 1. Model 2100A

SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The Model 2100A is a benchtop or ATE programmable instrument with a frequency range of 0.01Hz to 31.16MHz (synthesized down to 0.03Hz), and 7 digits of resolution with 0.5ppm accuracy. It has the versatility of a Function Generator and Sweep Generator, with high spectral purity, very low jitter (typically 2.5nsec), low harmonic distortion, and fast settling times. In addition, it is equipped with a Pulse Generator and a Sweep Ramp/Marker Generator for application flexibility.

Modes of operation include Continuous, Gate, Trigger Burst, Trigger Pulse, Lin/Log Sweep, and VC. The Main Output has a range of 10µV to 30V p-p open circuit, with a resolution of 3 digits, and is settable in rms or ac peak over the entire range.

The Main Generator consists of two generating systems, giving precise synthesized output waveforms of sine, square, triangle, positive and negative pulses with pulse rates up to 10MHz, linear and exponential ramps with ramp rates of up to 31.16kHz, and an auxiliary TTL.

The 2100A provides four ways to modify all parameter data entries; front panel keyboard, a settable ± "△" value in non-volatile memory, a settable multiply (X) or divide (÷) by "n" value in non-volatile memory, and a "data modifier knob" that will control the selected digit of any parameter by 24 digits/revolution.

Internal non-volatile memory permits the storing and recalling of 100 complete front panel set-ups within milliseconds. Single commands permit rapid interrogation of all stored data. Also branches can be entered to allow the user the flexibility of jumping from one set-up to another.

Included in the 2100A are fixed and variable dc offsets, output protection, three modes of audible tone selections for keystroke acknowledgment and error warnings, an internal clock for keeping track of up to 9999 hrs of operation time, a self-test of the logic circuits upon power-up, phase-lock monitors indicating a lock malfunction to the bus and the front panel, and extensive use of display messages.

All the features contained within the 2100A may be programmed via the IEEE-488 standard interface bus with simple mneumonic commands.

1.2 SPECIFICATIONS

WAVEFORMS : Sine, triangle, square, positive and negative pulses, linear and exponential ramps, auxiliary TTL; pulse rates up to 31.16MHz, ramp rates up to 31.16kHz.

FREQUENCY

Range : 0.03Hz (.01Hz unlocked) to 31.16MHz; synthesized over full range.

Accuracy : 0.5ppm. Optional ovenized reference; 0.01ppm.

Resolution : 7 digit display with minimum resolution of 1 part in 3 X 10^{5}; 10Hz at 3MHz to 31.16MHz, 1Hz at 300kHz to 3.116MHz, etc., all the way down to 10^{-7} Hz at .03Hz. Applies to all modes except VC and Sweep.

Stability : 0.5ppm. Optional ovenized reference; 0.01ppm.
Aging : ±1 ppm/yr. Optional ovenized reference; ±2 pp 10^{9}/day.
Temperature : ±1 ppm 0-50°C. Optional ±2 pp 10^{8} 0-60°C.

Jitter : <5nsec from 0.01Hz to 6MHz; <3% of period above 6MHz (measured on the squarewave transition.

MODES OF OPERATION

Continuous : Output frequency is synthesized and locked to a reference.

VC : (Voltage Control) Output frequency is set to within 3 or 4 digits ±1% and can be externally voltage controlled about the setting.

Gate : Allows the MAIN and TTL output to be externally gated on and off. Output frequency must be below 30kHz. The waveform start and stop points can be set between -90° to 267° with 1° resolution and ±1° accuracy.

Trig Burst : 1 to 255 cycles. Output frequency must be below 30kHz. The waveform start and stop points can be set between -90° to 267° with 1° resolution and ±1° accuracy.

Trig Pulse : Allows triggering of pulse waveform at rates up to a maximum of 10 X 10^{6} pulses/sec (pps).

Linear Sweep : Generator continuously linear sweeps between the start and stop frequencies.

Log Sweep : Generator continuously log sweeps between the start and stop frequencies.

SWEEP START/STOP RANGE : Up to .01Hz to 31.16MHz; more than 9 decades.

Accuracy : ±1%.
Resolution : 3½ digits.

NUMBER OF STEPS/SWP : Maximum of 256 steps for sweep times above 256ms, decreasing to 10 steps at 10ms sweep time.

SWEEP TIME : 10ms to 1000s; settable to 3 digits resolution down to .1s sweep time. Minimum resolution of 1ms below .1s. ±1%, ±.1ms accuracy.

SWEEP RAMP OUTPUT : 0V to 10V peak constant amplitude linear ramp. Maximum of 256 steps for sweep times above 256ms, decreasing to 10 steps at 10ms sweep time. Impedance, 600 ohms.

SWEEP MARKER OUTPUT : CMOS logic output; 600 ohm source impedance, low below marker frequency and high above marker frequency. With transition at marker frequency, levels are compatible with TTL.

MAIN OUTPUT

Range : 10µV to 15V p-p. Maximum output 30V p-p open circuit, 15V p-p into 50 ohms. Impedance, constant 50 ohms, ±1%. Protected from external voltages up to ±50V, current limited to 1amp continuous.

Resolution : 3 digits down to 10.0mV.

Accuracy (2kHz) : 1% of setting; 1.50V peak to 15V peak. 2% of setting; 15.0mV peak to 1.5V peak. 3% of setting; 1.5mV peak to 15mV peak.

Option 007 : Sinewave (peak), 0.05dB of setting 1.00V to 15V peak; 0.1dB of setting 10mV to 1.0V peak; 0.15dB of setting 1.0mV to 10mV peak. Sinewave (RMS), 0.05dB of setting ±½ LSD 0.71Vrms to 10.6Vrms; 0.1dB of setting ±½ LSD 7.1mVrms to 710mVrms; 0.15dB of setting ±½ LSD 0.71mVrms to 7.1mVrms.

DC COMPONENT : <±2% of peak amplitude setting.

FREQUENCY RESPONSE (10V p-p into 50 ohms ref from 2kHz)

Sine : 0.1dB to 500kHz, 0.2dB to 5MHz, 1.5dB to 31MHz.

Triangle : 0.2dB to 300kHz, 1dB to 3MHz, 3.5dB to 31MHz.

Option 007 : 0.025dB, 30Hz to 5MHz; 0.05dB, 10Hz to 10MHz; 0.1dB, 0.01Hz to 30MHz.

SINE DISTORTION	:	<0.05% from .01Hz to 5kHz, 0.1% to 15kHz, 0.25% to 100kHz, 0.5% from 100kHz to 500kHz, 1% to 1MHz. All harmonics at least 22dB below fundamental to 31MHz.
FIXED OFFSET	:	Sets waveform to half its p-p amplitude and sets the plus peak at zero for negative offset, and the minus peak at zero for plus offset. Reduces amplitude accuracy by 1%.
VARIABLE DC OFFSET	:	Allows setting the dc about ground from +12.7V peak to -12.7V peak. Fixed and variable offset may be used simultaneously. Maximum peak output, offset plus signal, limited to ±15V.
Resolution	:	3 digits. Optimized by MPU as a function of output amplitude and offset values. Can vary between 1 to 3 digits.
Accuracy	:	±1 count on the least significant digit.
TIME SYMMETRY	:	99.9% from 0.01Hz to 30kHz, 99% to 3MHz, 90% to 31MHz.
TRIANGLE LINEARITY	:	99% from 0.01Hz to 300kHz, 98% to 3MHz, 90% to 31MHz.
RAMP LINEARITY	:	99.5% to 1kHz, falling to 99% to 30kHz.
EXPONENTIAL	:	2 cycles of exponential ramp.
RETRACE TIME	:	10% of ramp cycle.
SQUAREWAVE RISE/FALL	:	<11ns with <5% aberrations into 50 ohm termination for outputs >0.15V p-p. 10% for outputs from 0.10V to 15mV p-p.
PULSE RISE/FALL	:	<11ns with <5% aberrations into 50 ohm termination for outputs >0.15V p-p. 10% for outputs from 0.10V to 15mV p-p.
PULSE WIDTH	:	50ns to 1.27s with 2½ digits resolution. ±2% ±5ns from 1.3µs to 1.27s; ±5% ±10ns from 50ns to 127ns; Minimum duty cycle 50%.
PULSE RATE	:	Maximum rep-rate of 10×10^6 pulses/sec. Accuracy; 0.5ppm. Optional ovenized reference; 0.01ppm.

SIGNAL TO PHASE NOISE

In a 30kHz bandwidth centered on the carrier, excluding 1Hz band at center:

>-35 dBc; 3MHz to 30MHz
>-55 dBc; 300kHz to 3MHz
>-75 dBc; 30kHz to 300kHz
>-100dBc; below 30kHz

Single sideband phase noise in a 1Hz bandwidth, offset 5kHz from the carrier:

>-60dBc; 3MHz to 30MHz
>-80dBc; 300kHz to 3MHz
>-90dBc; 30kHz to 300kHz

SPECTRAL PURITY

Non-harmonically related components:

>-30dBc; above 3MHz
>-50dBc; 30kHz to 3MHz
>-80dBc; below 30kHz or 30µV, whichever is greater.

DATA RESPONSE TIME : Under 100ms for all entries.

1.3 INPUT CONNECTORS

Trig Input : Front panel BNC (rear panel optional); >1V to turn on, <.5V to turn off. Impedance, 20k ohms below ±5V, 2k ohms above ±5V. Maximum allowable voltage, ±35V. Becomes activated in the GATE, TRIG BURST, or TRIG PULSE modes.

VC Input : Front panel BNC (rear panel optional); 100:1 frequency control with an external voltage. Impedance, 6k ohms below ±5V, 2k ohms above ±5V. Maximum allowable voltage, ±35V. 3 volt operating range.

External Ref Input : Rear panel BNC, selected with rear panel slide switch. Requires a 10.00000MHz, 1V to 5V p-p input.

Accuracy : Same as external reference.
Stability : Same as external reference.
Impedance : 10k ohms in parallel with a 15pf.

1.4 OUTPUT CONNECTORS

Main Output : Front and rear panel BNC (switch selectable). 30V p-p open circuit, 15V p-p into 50 ohms. Impedance, constant 50 ohms.

Ramp Output	:	Front panel BNC (rear panel optional). 0 to +10V peak. Impedance, 600 ohms.
Marker Output	:	Front panel BNC (rear panel optional). CMOS logic output. Impedance, 600 ohms.
TTL Output	:	Front panel BNC (rear panel optional). 50% duty cycle when sine, square, or triangle waveforms are on the MAIN output. Same pulse width as pulse on MAIN output but 180° out of phase. Can drive 10 TTL loads. Impedance, constant 50 ohms.
Rise/Fall	:	<6ns with <10% aberrations into 50 ohm terminator.
Internal Ref Output	:	Rear panel BNC, 10MHz, 5V, HCMOS output.
Accuracy	:	0.5ppm, Optional ovenized reference; 0.01ppm.
Stability	:	Aging; ±1 ppm/yr. Optional ovenized reference; ±2 $pp_8 10^9$/day. Temperature; ±1ppm 0-50°C. Optional ±2 pp 10^8 0-60°.

1.5 SALIENT FEATURES

Non-Volatile Memory : Storage of up to 100 complete front panel set-ups.

PRESETS		DESCRIPTION
[-] [1] [RECALL]	:	Sets the unit to neutral base conditions of 1kHz, CONT, 0V AC PEAK, 0V DC OFFSET, Sinewave. n=10 for all parameters when using the [Xn] and [÷n] keys.
[-] [2] [RECALL]	:	Sets the amplitude n value for a 10dB change each time the [Xn] and [÷n] keys are pressed. n=3.162278.
[-] [3] [RECALL]	:	Sets the amplitude n value for a 1dB change each time the [Xn] and [÷n] keys are pressed. n=1.122018.
[-] [4] [RECALL]	:	Sets the waveform to sinewave and the ac amplitude to 0dBm into a 50 ohm load; it also displays volts in AC RMS. Volts rms=.447V.
[-] [5] [RECALL]	:	Sets the output amplitude for TTL levels.
[-] [6] [RECALL]	:	Sets the output for ECL levels into a 50 ohm load.
[-] [7] [RECALL]	:	Sets the frequency of the Generator to the color burst frequency of 3.579545MHz.
[-] [8] [RECALL]	:	Sets the frequency n value to $\sqrt[5]{10}$. n=1.584893.
[-] [9] [RECALL]	:	Sets all parameter n values to 1.01 for 1% changes.
[-] [9] [9] [RECALL]	:	Sets the unit to schematic test conditions.

1.6 GPIB PROGRAMMING

Subsets	:	SH1, AH1, T6, L4, SR1, RL1, PP1, DC1, DT1, C0, E1
Line Termination	:	The operator may select between ASCII CR, LF, CR/LF, LF/CR, or none. The GPIB OEI signal is always sent with the last character on a line.
Talker Function	:	Allows interrogation of the 2100A by a controller.

1.7 GENERAL

Operating Temperature Range	:	0°C to 50°C.
Power Requirements	:	Switch selectable, 90-110, 108-132, 198-242, 216-264 volts, single phase, 50-60Hz. Power consumption; 90 watts maximum.

DIMENSIONS AND WEIGHT

Cabinet Size : 5¼"/13.3cm high, 16 5/8"/42.4cm wide, 16½"/41.9cm Service Department. The location of all test points and adjustable components may be found in the component layout drawings at the rear of this manual.

OPTIONS

003: Rear panel BNC connectors for TRIG INPUT, VC INPUT, MARKER OUTPUT, TTL OUTPUT.
005: Bus opto-isolation.
006: High Stability reference, 0.01ppm.
007: Flat response (not available with OUTPUT PROTECTION).
RK-516: Rack mount kit for standard 19" racks.

SECTION 2

OPERATION

2.1 INTRODUCTION

This section describes the basic operation of the Model 2100A. It includes the proper ac requirements, the recommended turn-on procedure and a detailed explanation of all operating controls and modes of operation.

2.2 POWER REQUIREMENTS

The 2100A is designed to operate from a single phase, 50-60Hz ac power source of 90-110, 108-132, 198-242 or 216-264 volts. The line switches on the rear panel allow the 2100A to be powered from one of the four selections just described. The ac power receptacle, on the rear panel, is a standard 3-pin connector and complies with the European I.E.C. standard. A detachable line cord is provided with the instrument.

The fuse receptacle contains a properly rated fuse for the instrument's point of destination's power requirements.

2.3 TURN-ON PROCEDURE

a. Set the line switches for the correct voltage range.

   For 90-110 volts, set the 120V/240V switch to 120V and the NORM/LO switch to LO. The fuse should be 1.50 amp.

   For 108-132 volts, set the 120V/240V switch to 120V and the NORM/LO switch to NORM. The fuse should be 1.50 amp.

   For 198-242 volts, set the 120V/240V switch to 240V and the NORM/LO switch to LO. The fuse should be .75 amp.

   For 216-264 volts, set the 120V/240V switch to 240V and the NORM/LO switch to NORM. The fuse should be .75 amp.

b. Make sure the power switch is in the off position.

c. Plug the line cord into the unit and into an ac outlet.

WARNING!

The chassis of this instrument is connected to ground. For safety purposes, connect the line cord to a grounded, 3 terminal ac outlet.

d. Turn the power on and allow the unit to warm-up for 30 minutes to achieve rated accuracies.

CAUTION!

Because of potentially dangerous voltages that exist within the unit, the covers of this instrument should not be removed while the instrument is connected to an ac power source.

2.4 SELF-TEST

When the 2100A is turned-on, the microprocessor performs a Self-Test routine whereby the entire RAM and ROM operation are verified. During the test, the front panel LED's and the DATA display will turn-on and turn-off in the following manner:

1. The 7 LED's above the [MODE], [CYCLES/BURST] and [MAN TRIG] keys and the 4 LED's above the [START PHASE] key.
2. The DATA display.
3. The REMOTE LED, all the MULTIPLIER/PARAMETER LED's, and the 9 LED's above the [SELECT] key.

If there is a malfunction with the Microprocessor board, such as a defective RAM or ROM, the sequence will stop and "bAd" will appear on the display and a number from 1-5 indicating which device is defective. The following is a list of the component that is defective and needs to be replaced:

1. bAd 1 U638, DS1225
2. bAd 2 U635, 2764
3. bAd 3 U634, 2764
4. bAd 4 U631, 2764
5. bAd 5 U629, 2764

When the Self-Test is complete, the 2100A will return to the last set-up before the unit was turned on or the Self-Test initiated. Once the unit is operational, the Self-Test can be repeated by pressing [SECOND FUNCTION] [− FIXED OFFSET].

The 2100A is now ready for operation.

2.5 FRONT PANEL

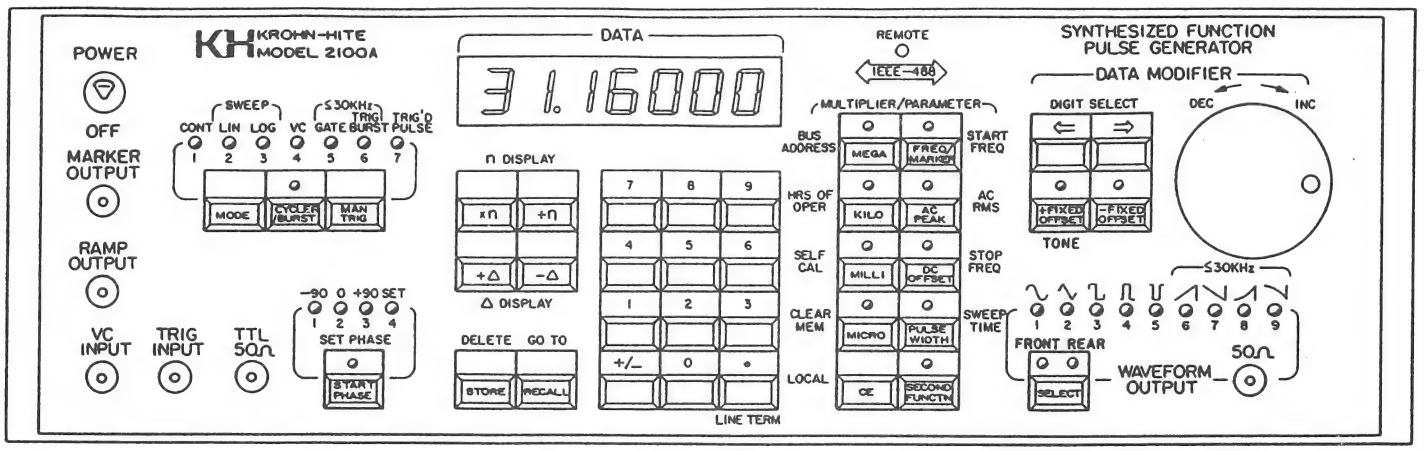


Figure 2.1

2.5.1 Mode, Cycles/Burst, and Man Trig keys:

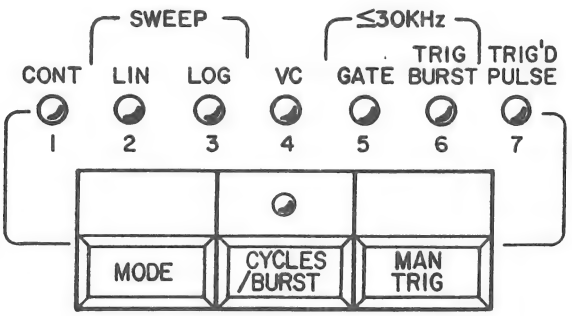


Figure 2.2.

[MODE] key : Selects the following Modes of Operation:

Continuous; Locked to reference. Sweep (Linear or Log); Unlocked from reference. VC (Voltage Control); Unlocked from reference. Gate (Frequencies must be ≤30kHz). Trig Burst (Frequencies must be ≤30kHz). Trig'd Pulse (Waveform must be selected for PULSE).

NOTE: MODES of operation can also be selected by entering the desired number with the DATA keys, with the corresponding number below the LED's, then press the [MODE] key.

[CYCLES/BURST] : Enters and/or displays the number of cycles in the burst.

[TRIG] : Initiates manual gate or trigger.

2.5.2 Start Phase key:

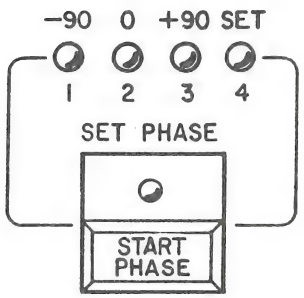


Figure 2.3.

[START PHASE] : Operates in the following manner:

1. Each time pressed, the phase will move to -90°, 0°, +90°, or SET. The lit LED indicates the phase selected.

2. Pressing [SECOND FUNCTION] then [START PHASE], will display the SET phase. The lit LED in the key indicates SET PHASE is in the display. To display another parameter, simply press that parameter.

SET PHASE

1. To set the phase to a desired setting (from -90° to +267°), simply enter the number and press [SECOND FUNCTION] [START PHASE].

2. To increment/decrement the phase manually, put the Start Phase in the SET position. Display the Start Phase as in Step 2 above. Select the desired digit by pressing either DIGIT SELECT keys (each time pressed, a digit will become intensified). This will activate the DATA MODIFIER knob, which will then allow incrementing when turned to the right and decrementing when turned to the left.

NOTE: START PHASE can also be selected by entering the corresponding desired number below the LED's with the DATA keys, then press the [START PHASE] key.

2.5.3 DATA Display and DATA, Xn, ÷n, +△, and -△ keys:

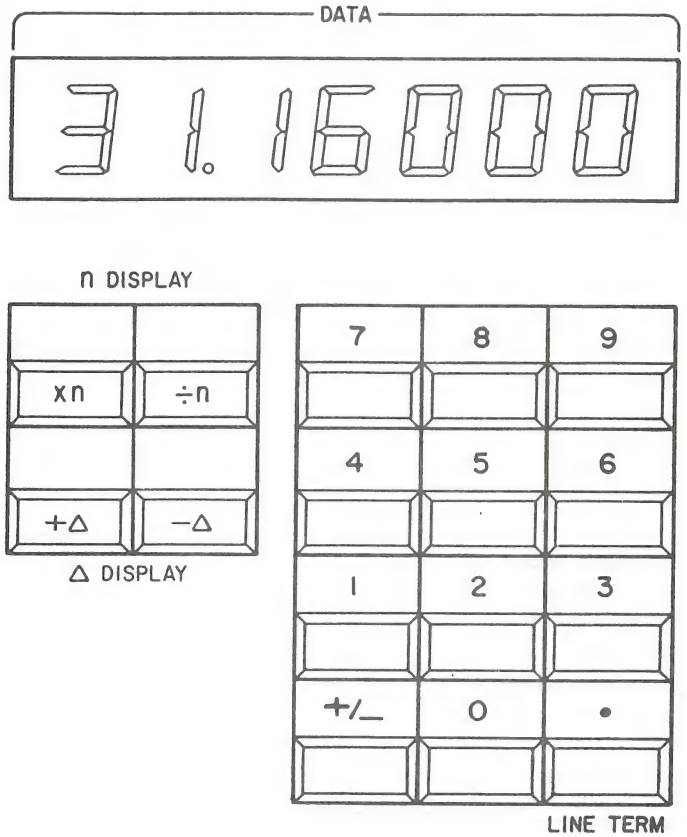


Figure 2.4.

DATA keys [0]-[9], [+/-], and [.] enter the numerical value of the parameter selected, i.e. frequency, amplitude, etc. The DATA is displayed by a 7 digit display.

[Xn] [÷n] : 1. Multiplies/divides the displayed parameter value by the the number "n". To select a value press the desired DATA keys then [xn] or [÷n]. Each time the [Xn] or the [÷n] key is pressed it will multiply/divide the displayed parameter by the "n" value. The value entered will time out in approximately 3 seconds and return the display to the previous parameter. Pressing any key will also clear it.

2. To display what the "Xn" or the "+n" value is, press [SECOND FUNCTION] [Xn] or [SECOND FUNCTION] [+n]. The display again will time out in approximately 3 seconds and return to the previous parameter value.

NOTE: Each parameter can have its own independent n value.

[+△], [-△] : 1. Adds/subtracts the displayed parameter value by the the number "△". To select a value press the desired DATA keys then [+△] or [-△]. Each time the [+△] or the [-△] key is pressed it will add/subtract the displayed parameter by the "△" value.

2. To display what the "+△" or the "-△" value is, press [SECOND FUNCTION] [+△] or [SECOND FUNCTION] [-△]. The displayed value will time out in approximately 3 seconds and return to the previous parameter value.

NOTE: Each parameter can have its own independent △ value.

2.5.4 Store and Recall keys:

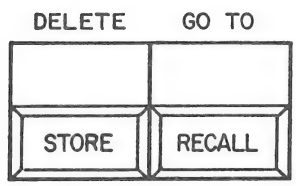


Figure 2.5.

[STORE] : Operates in the following manner:

: 1. When pressed, the display will indicate "Sto.##". The number "##" that appears in the display, is the next non-volatile memory location available for storing information. Pressing [STORE] again will store the entire front panel set-up into that location. Pressing [CE] will will restore the display to its previous set-up.

2. Pressing [#] [STORE] will enter the Front Panel set-up into "#" location directly.

NOTE: If there is data in the memory location selected, the data will be inserted at that location and all other data will move up one location number, i.e. 3 will become 4, 4 will become 5, etc., it is NOT deleted.

DELETE : When preceded by a DATA key from [0]-[99] and [SECOND FUNCTION], the data in the selected memory location will be deleted. All other data will be moved down one memory location, i.e. 3 will become 2, 2 will become 1, etc.

[RECALL] : Operates in the following manner:

1. When proceeded by a DATA key, [0]-[99], it displays and outputs all the instruments parameters stored in that memory location.

2. When not proceeded by a DATA key, the display will indicate "rcl ##". The number "##" is the next data location to be recalled. Pressing [RECALL] again, recalls that memory location.

GO TO : GO TO is for programming loops or branches into the unit. It operates in the following manner:

1. Enter the desired memory location where the loop or branch will leave from by pressing [#] [RECALL] or [#] [SECOND FUNCTION] [GO TO]. Using the GO TO will not recall the DATA at #. This step is not necessary if at the branch point.

2. Press [SECOND FUNCTION] [GO TO]. "Goto --" will be displayed. The "--" are prompts for entering the memory location desired. Simply enter the desired memory location the unit will loop or branch to and press [STORE] [STORE]. The branch is now completed. For locations below 10, a zero must be entered to fill the first digit, then the location number, i.e. 03, 04, 05, etc.

2.5.5 Multiply/Parameter keys:

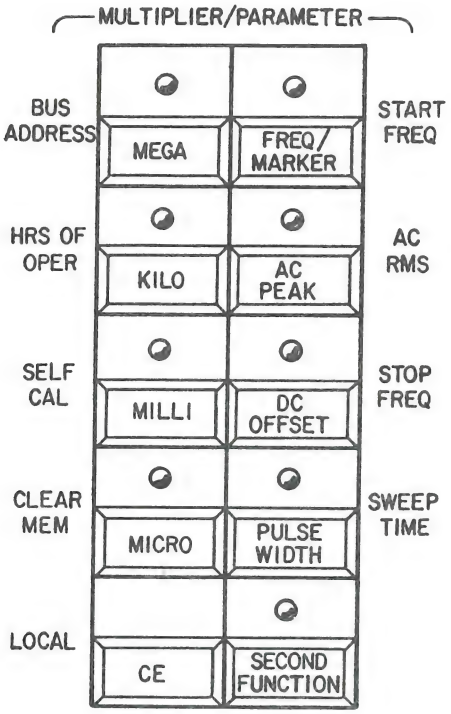


Figure 2.6.

[MEGA] : Multiplies the numerical DATA by 10^{6}.

[KILO] : Multiplies the numerical DATA by 10^{3}.

[MILLI] : Multiplies the numerical DATA by 10^{-3}.

[MICRO] : Multiplies the numerical DATA by 10^{-6}.

Note: If no multiplier is selected, the basic units for the Parameter applies, i.e. volts, Hertz, seconds, etc.

[CE] (Clear entry) : Operates in the following manner:

1. Clears current DATA entry and restores the display to its previous Parameter as long as a parameter has not been selected.

2. Clears current Parameter entry and restores display and unit operation to its previous parameter entry. When pressed again, toggles back to the current entry. Each time [CE] is pressed, it will toggle back and forth between the last two (2) entries made.

[FREQ/MARKER] : Enters and/or displays the frequency or the marker frequency in hertz.

[AC PEAK] : Enters and/or displays the open circuit output voltage as ac peak.

[DC OFFSET] : Enters and/or displays the open circuit dc offset on the output signal. Numeric value and polarity are selected by the DATA keys prior to entering dc offset.

[PULSE WIDTH] : Enters and/or displays the pulse width.

[SECOND FUNCTION] : When pressed, allows the second function of a key to be engaged. The **WHITE** lettering on the Front Panel corresponds to the second functions available.

2.5.5.1 Second Functions of the Multiply/Parameter keys:

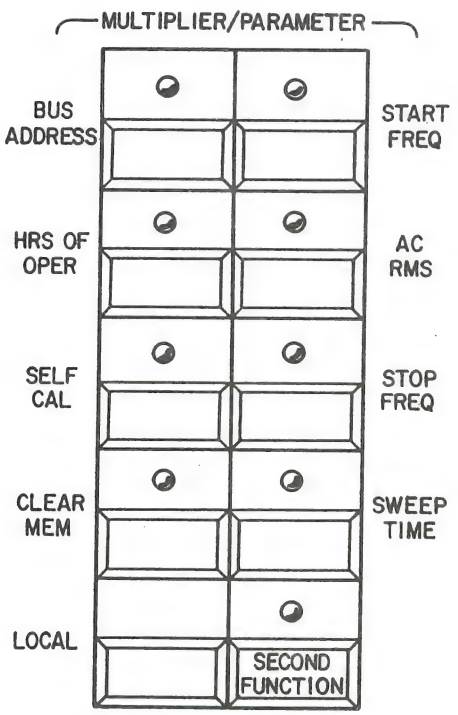


Figure 2.7.

This section describes the operation of the [SECOND FUNCTION] key in conjunction with the Multiply/Parameter keys. When pressed, all the **WHITE** labeling on the Front Panel next to a specific key becomes that function.

BUS ADDRESS [MEGA] : Enters and/or displays the IEEE-488 primary bus address. When preceded by a DATA key, it enters the IEEE-488 bus address selected. When not preceded by a DATA key, it displays the IEEE-488 address currently being used. The settable range for the address is 0-30.

HRS OF OPER [KILO] : Displays the hours of operation that the unit has accumulated up to 9999. To reset the hours of operation back to zero (0), turn the unit off, hold down the HRS OF OPER [KILO] key, then turn on the unit.

SELF CAL [MILLI] : Engages the self-calibration function of the unit. When engaged, the unit begins its self-calibration cycle at 30.72MHz, and finishes at 30kHz. When completed, the unit will return to its previous set-up.

To abort the self-calibration cycle, press the [CE] key. The unit will complete the frequency it is on and return to the previous set-up.

CLEAR MEM [MICRO] : When pressed, the display will indicate "r.u. SurE". This is a precaution for the user in case he pressed the wrong key by accident. To clear the memory, simply press [SECOND FUNCTION] [CLEAR MEM] again. Memory will be cleared and the store pointer will set to zero location.

NOTE: The display will time out in approximately 3 seconds and return to the previous parameter, or pressing another parameter key will display that parameter. The time out only pertains to BUS ADDRESS, HRS OF OPER, SELF CAL.

START FREQ [FREQ/MARK] : Enters and/or displays the Sweep mode start frequency.

AC RMS [AC PEAK] : Enters and/or displays the open circuit output voltage in ac rms.

STOP FREQ [DC OFFSET] : Enters and/or displays the Sweep mode stop frequency.

SWEEP TIME [PULSE W] : Enters and/or displays the sweep time in seconds.

2.5.6 Digit Select keys and Data Modifier Knob:

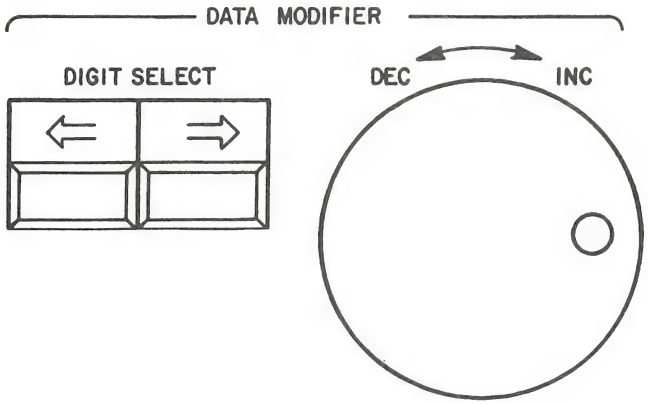


Figure 2.8.

[⟵],[⟶] : 1. When [⟵] or [⟶] is pressed, it advances the intensified digit from right to left or from left to right. The intensified digit represents the DATA MODIFIER knob resolution (its operation is 24 counts/revolution).

2. To disengage the digit select, continue pressing the [⟵] or the [⟶] key until there is no intensified digit.

3. Each Parameter can have an independent DIGIT SELECT.

4. When entering DATA, the [⟵] key functions as a last number entered rub-out.

DATA MODIFIER : Turning the knob to the left decrememnts the intensified digit in the display. Turning the knob to the right increments the intensified digit in the display. The range is approximately 24 counts per revolution.

NOTE: There must be an intensified digit in the display in order for the DATA MODIFIER to function.

2.5.7 Fixed Offset keys:

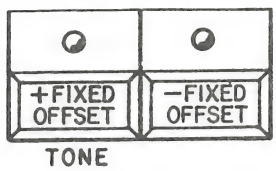


Figure 2.9.

[+ FIXED OFFSET] : Halves the Main Output peak-to-peak amplitude and sets the waveform negative peak to zero volts.

[- FIXED OFFSET] : Halves the Main Output peak-to-peak amplitude and sets the waveform positive peak to zero volts.

2.5.7.1 Second Function of the + Fixed Offset Key

TONE [+ FIXED OFFSET] : Pressing [SECOND FUNCTION] [TONE], allows the Tone Generator to be programmed in one of three (3) modes.

1. "no tonE"; The Tone Generator is disengaged. It will NOT sound at any time.

2. "ErrtonE"; The Tone Generator will sound only when an error occurs during operation.

3. "FulltonE"; The Tone Generator will sound when Front Panel keys are engaged and when errors occur during operation.

NOTE: Display will time out in approximately 3 seconds and return to the previous set-up. Pressing any other key will also clear it. Tone selection can also be accomplished by entering [0] [SECOND FUNCTION] [TONE] for "No Tone", [1] [SECOND FUNCTION] [TONE] for "Error Tone", and [2] [SECOND FUNCTION] [TONE] for "Full Tone.

2.5.8 Select key:

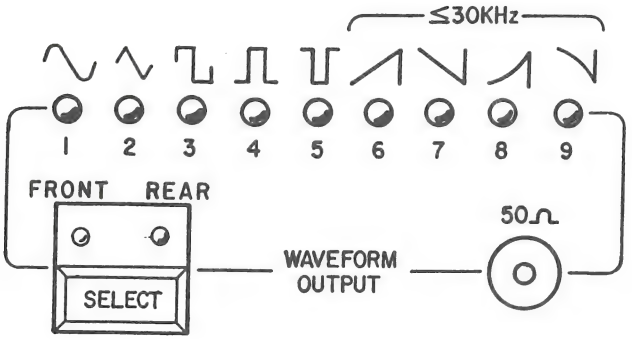


Figure 2.10

[SELECT] : Selects desired waveform.

NOTE: Selecting a waveform can also be accomplished by entering the corresponding desired number below the LED's, then press the [SELECT] key.

2.5.8.1 Second Function of the Select key:

FRONT [SELECT] or REAR : Pressing [SECOND FUNCTION] [SELECT] will toggle the Main Output to either the FRONT or REAR panel. The corresponding LED will be lit.

2.5.9 LED Indicators:

REMOTE : LED on indicates Remote programming status. Pressing LOCAL, [CE], returns programming control to the Front Panel (local).

2.5.10 Connectors (BNC):

MARKER OUTPUT : 5V CMOS logic output. Impedance; 600 ohms.

RAMP OUTPUT : 0 to +10V peak. Impedance; 600 ohms.

VC INPUT : 100:1 frequency control with an external voltage. Impedance; 6k ohms below ±5V, 2k ohms above ±5V. Maximum allowable voltage is ±35V. Normal operating range is 3V.

TRIG INPUT : >1V to turn on, <.5V to turn off (can be internally set to other levels). Impedance; 20k ohms below ±5V, 2k ohms above ±5V. Maximum allowable voltage is ±35V. Becomes activated in the GATE, TRIG BURST, and TRIG'D PULSE modes of operation.

TTL : 50% duty cycle when Sine, Square, and Triangle waveforms are on the Main Output. Same pulse width as the PULSE on the Main Output, but 180° out of phase. Can drive 10 TTL loads. Impedance; constant 50 ohms. Rise/fall time <6ns with 10% aberrations into 50 ohm terminator.

MAIN OUTPUT (50Ω) : Front or rear panel BNC, switch selectable. 30v p-p open circuit, 15V p-p into 50 ohms. Impedance; constant 50 ohms.

2.6 REAR PANEL

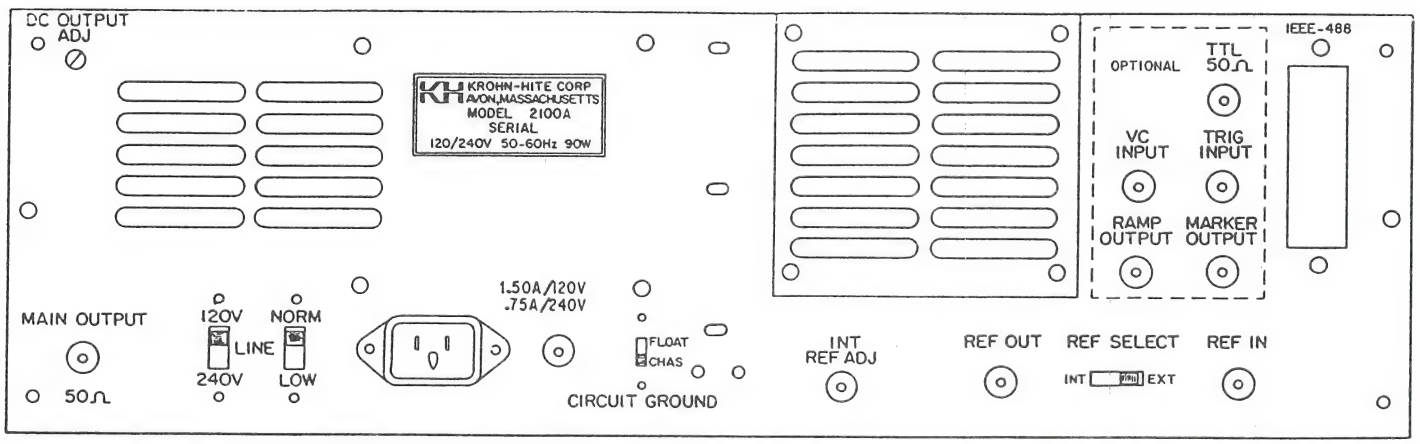


Figure 2.11

2.6.1 Connectors (BNC):

MAIN OUTPUT (50Ω) : Front or rear panel BNC, switch selectable. 30v p-p open circuit, 15V p-p into 50 ohms. Impedance; constant 50 ohms.

REF OUT : 10MHz, 5V, HCMOS output. Internal accuracy: 0.5ppm (Optional ovenized reference; 0.01ppm). Stability: AGING; ±1ppm/yr (Optional ovenized reference; ±2pp 10^{9}/day). TEMPERATURE: ±1ppm 0-50°C (Optional ±2pp 10^{8} 0-60°C). External accuracy: Same as external reference.

EXT REF IN : Selectable with rear panel slide switch. Requires a 10.00000MHz, 1V to 5V p-p input. Accuracy: Same as external reference. Impedance; 10k ohm in parallel with a 15pf.

IEEE STD-488 PORT : Standard IEEE-488 interface.

2.5.2 Optional Rear BNC's:

MARKER OUTPUT : 5V CMOS logic output. Impedance; 600 ohms.

RAMP OUTPUT : 0 to +10V peak. Impedance; 600 ohms.

VC INPUT : 100:1 frequency control with an external voltage. Impedance; 6k ohms below ±5V, 2k ohms above ±5V. Maximum allowable voltage is ±35V. Normal operating range is 3V.

TRIG INPUT : >1V to turn on, <.5V to turn off (can be internally set to other levels). Impedance; 20k ohms below ±5V, 2k ohms above ±5V. Maximum allowable voltage is ±35V. Becomes activated in the GATE, TRIG BURST, and TRIG'D PULSE modes of operation.

TTL : 50% duty cycle when Sine, Square, and Triangle waveforms are on the Main Output. Same pulse width as the PULSE on the Main Output, but 180° out of phase. Can drive 10 TTL loads. Impedance; constant 50 ohms. Rise/fall time <6ns with 10% aberrations into 50 ohm terminator.

2.6.3 Power:

LINE : Switches to select 120V/240V and NORM/LOW ac line.

RECEPTACLE : Standard 3 pin.

FUSE : 1.50 amp slow-blow for 120V, .75 amp for 240V.

2.6.4 Switches:

OUTPUT SELECT : Slide switch for selecting front or rear panel Main Output.

CIRCUIT GROUND : Slide switch for selecting FLOATing or CHASsis ground.

REF SELECT : Slide switch for selecting INTernal or EXTernal reference.

2.7 PRIMARY KEYBOARD OPERATION

The front panel keyboard controls all operations of the instrument. [-] [9] [9] [RECALL] will return all parameters and second functions to the following set-up , which are the schematic test conditions:

MODE	:	Continuous
START PHASE	:	0°
SET PHASE	:	180°
FREQUENCY	:	2kHz
WAVEFORM	:	Sine
AMPLITUDE	:	5 volts ac peak
DC OFFSET	:	0 volts
PULSE WIDTH	:	10µsec
START FREQUENCY	:	10Hz
STOP FREQUENCY	:	1MHz
SWEEP TIME	:	250ms
CYCLES/BURST	:	1
Xn and ÷n	:	10
+△ and -△	:	1

[+ FIXED OFFSET] and [- FIXED OFFSET] operate in a toggle fashion.

The following keys have an auto repeat; [MODE], [START PHASE], [xn], [÷n], [+△], [-△], [STORE], [RECALL], [CE], [DIGIT SELECT], [←], [→], and [WAVE-FORM SELECT].

2.7.1 Examples of Keyboard Commands:

1. To select a mode of operation and a waveform, simply press the [MODE] key and the [SELECT] key until the corresponding LED's light.

2. To enter a parameter, press the appropriate DATA key(s), followed by a MULTIPLY key, if desired, and the desired parameter. The following keys are Primary and Secondary PARAMETER keys:

   a. Primary parameters: [FREQ/MARKER], [AC PEAK], [DC OFFSET], [PULSE WIDTH], [CYCLES/BURST].

   b. Secondary parameters (are in WHITE lettering and must be preceded by the [SECOND FUNCTION] key): [START FREQUENCY], [AC RMS], [STOP FREQUENCY], [SWEEP TIME] and [SET PHASE].

   EXAMPLE, Enter the following:

1kHz	:	[1] [KILO] [FREQ]
5 volts ac peak	:	[5] [AC PEAK]
2 volts dc offset	:	[2] [DC OFFSET]

3. To display a parameter (not change), simply press the appropriate parameter key.

4. The DATA display will automatically downrange and uprange. For example: If .123V ac peak is entered, it will be displayed as 123mV ac peak.

2.7.2 Sweep Modes:

Sweeps are generated by entering the Sweep Mode, either linear (LIN) or logarithmic (LOG). The start and stop frequencies and the sweep time can all be set via the front panel.

EXAMPLE #1

To generate a repetitive linear sweep that starts at 200Hz and stops at 10kHz, and has a sweep time of 900ms:

1. Press [2] [0] [0] [SECOND FUNCTION] [START FREQ]
2. Press [1] [0] [KILO] [SECOND FUNCTION] [STOP FREQ]
3. Press [9] [0] [0] [MILLI] [SECOND FUNCTION] [SWEEP TIME]
4. Enter the linear sweep mode by pressing the [MODE] key until the LIN LED is lit.

EXAMPLE #2

To generate a repetitive logarithmic sweep that starts at 100Hz and stops at 100kHz, and has a sweep time of 200ms:

1. Press [1] [0] [0] [SECOND FUNCTION] [START FREQ]
2. Press [1] [0] [0] [KILO] [SECOND FUNCTION] [STOP FREQ]
3. Press [2] [0] [0] [MILLI] [SECOND FUNCTION] [SWEEP TIME]
4. Enter the logarithmic sweep mode by pressing the [MODE] key until the LOG LED is lit.

NOTE: If the value of a desired parameter is outside of the instruments specified limits, the display will indicate "hi EntrY" or "LoEntrY". The display will then time out in approximately 3 seconds or enter a value that is within specified limits.

When Start and/or Stop frequencies, or Sweep times of less than 256ms are changed, the sweep DATA must be set-up before sweeping starts. This will be a delay of approximately 3 seconds before the sweep starts. These parameters may be changed on the fly while in the sweep mode with the set-up delay taking place.

The Marker frequency and Sweep times of greater than 256ms require no set-up time. Once the Sweep parameters have been set-up, leaving and re-entering the Sweep mode requires no set-up time at all and sweeping will resume immediately.

2.7.3 Frequency Marker:

When in the Sweep Mode, the Continuous mode frequency setting, becomes the Marker Frequency. The point where the sweep crosses the Main Generator frequency is the Mark Point. Figure 2.12 illustrates the use of the Frequency Marker at the -3dB point of a 1MHz Low Pass Filter. The Mark Point is the point where the MARKER OUTPUT switches from a low state to a high state.

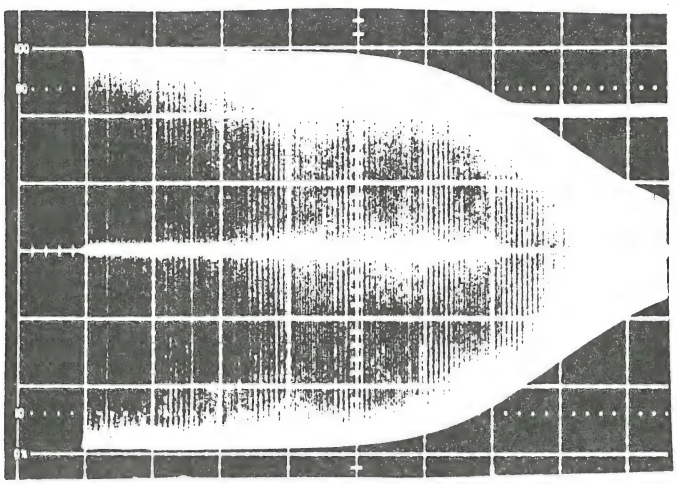


Figure 2.12 Marker Operation.

2.7.4 VC Mode (External Frequency Control):

The Generator frequency may be controlled by an external voltage applied to the VC INPUT. A control voltage range of 3 volts will vary the frequency about the setting of the Generator, up to a maximum of 100:1, limited by the maximum frequency setting on a multiplier range. Frequency multiplier ranges are decade multiples covering 3 to 31.16, with a hysterisis of 1.16 between ranges; such as 3kHz to 31.16kHz. The maximum allowable voltage that may be applied to the VC INPUT without causing damage is ±35Vdc.

A useful application for the VC INPUT is applying a sinewave signal to the VC INPUT to modulate (FM) the Main Output frequency about the Generator frequency setting.

2.7.5 Gate Mode:

The GATE mode allows the Main Output and the TTL Output to be externally or manually gated on and off. However, the output frequency must be 30kHz or below. The waveform start and stop points can be set between -90° to 267°, with 1° resolution and ±1° accuracy (frequency is locked to the reference).

To generate a continuous output for the duration of the external/manual gate:

1. Press [5] [MODE].
2. Select the desired frequency.
3. Press the [START PHASE] key until the desired phase is selected. If a phase other than -90, 0, and +90 is desired, press [4] [START PHASE]. Now press [SECOND FUNCTION] [START PHASE] to display what the start phase is set to. Now select the desired phase by pressing [#] [SECOND FUNCTION] [START PHASE]; [#] is the desired phase the unit is to be set to.
4. Apply the external gate into the TRIG INPUT or press [MAN TRIG].

2.7.6 Trigger Burst Mode:

The TRIG BURST mode allows the Generator to output 1 to 255 waveform cycles, that can be externally or manually triggered on. However, the output frequency must be 30kHz or below. The waveform start and stop points can be set between -90° to 267°, with 1° resolution and ±1° accuracy (frequency is locked to the reference).

To generate a triggered burst of 8 cycles at 1kHz with a rep-rate of 20ms:

1. Press [6] [MODE].
2. Press [1] [KILO] [FREQ/MARKER].
3. Press [8] [CYCLES/BURST]:
4. Press the [START PHASE] key until the desired phase is selected. If a phase other than -90°, 0°, and +90° is desired, press [4] [START PHASE]. Now press [SECOND FUNCTION] [START PHASE] to display what the start phase is set to. Now select the desired phase by pressing [#] [SECOND FUNCTION] [START PHASE]; [#] is the desired phase the unit is to be set to.
5. Set the external trigger source for 200Hz (20ms) and apply the external trigger into the TRIG INPUT.

2.7.7 Triggered Pulse Mode:

The TRIG'D PULSE mode allows the Generator to output pulses manually or with an external trigger, that are settable between 50ns to 1.27s with 2½ digits of resolution. The rise and fall time is <11ns, and the maximum pulse rep-rate is 10,000,000 pulses/second.

To output a triggered pulse with a 50µs pulse width and a rep-rate of 500µs:

1. Press [4] or [5] [SELECT] for positive or negative pulse waveform.
2. Press [7] [MODE].
3. Press [5] [0] [MICRO] [PULSE WIDTH].
4. Set the external trigger source to 2kHz (500µs) and connect it to the TRIG INPUT.

2.8 PRESETS

In addition to the user defined front panel set-ups ([RECALL] [0]-[99]), the 2100A has a library of built-in presets available which are on recall with only a few keystrokes. They are:

[-] [1] [RECALL] : Sets the unit to neutral base conditions of 1kHz, CONT, 0V AC PEAK, 0V DC OFFSET, Sinewave. n=10 for all parameters when using the [xn] and [÷n] keys.

[-] [2] [RECALL] : Sets the amplitude n value for a 10dB change each time the [xn] and [÷n] keys are pressed. n=3.162278.

[-] [3] [RECALL] : Sets the amplitude n value for a 1dB change each time the [xn] and [÷n] keys are pressed. n=1.122018.

[-] [4] [RECALL] : Sets the waveform to sinewave and the ac amplitude to 0dBm into a 50 ohm load; it also displays volts in AC RMS. Volts rms=.447V.

[-] [5] [RECALL] : Sets the output amplitude for TTL levels.

[-] [6] [RECALL] : Sets the output for ECL levels into a 50 ohm load.

[-] [7] [RECALL] : Sets the frequency of the Generator to the color burst frequency of 3.579545MHz.

[-] [8] [RECALL] : Sets the frequency n value to $\sqrt[5]{10}$. n=1.584893. Gives 5 frequencies/decade for plotting.

[-] [9] [RECALL] : Sets all parameter n values to 1.01 for 1% changes.

[-] [9] [9] [RECALL]: Sets the unit to schematic test conditions.

2.9 COLD START

The Cold Start feature of the 2100A is provided for helping the user when troubles occur. If there ever happens to be a failure or the unit does not seem to be operating properly, refer to the Maintenance Section of this manual.

2.10 ENTERING AND DISPLAYING THE SERIAL NUMBER

The 2100A has a means of entering and displaying the serial number. It is initially entered into the unit at the factory during testing and the only time it would ever need to be entered again, is after a COLD START. The following is the procedure for entering and displaying the serial number of the unit:

1. To display the serial number:

   Press [SECOND FUNCTION] [←—]: The display will indicate "Sn ###". The display will time out in approximately 3 seconds and return to the previous parameter.

2. To enter the serial number after a COLD START:

> **WARNING!**
>
> Do not press [SECOND FUNCTION] [←—] to display the serial number until the serial number of the unit has been entered by the following procedure!

   Press [#] [#] [#] [SECOND FUNCTION] [←—]: The serial number has now been entered into non-volatile memory. The serial number can now be displayed.

2.11 DISPLAYING THE SOFTWARE VERSION

The software version for the unit has been stored in ROM and can be displayed at any time. To display the software version:

Press [SECOND FUNCTION] [—→]: The display will indicate "SoFt. #.#". The display will time out in approximately 3 seconds and return to the previous parameter.

SECTION 3

IEEE-488 STD (GPIB) PROGRAMMING

3.1 INTRODUCTION

The Model 2100A remote programming interface accepts both ASCII data commands and IEEE-488 standard interface commands for control of the unit.

In presenting the information required to program the 2100A via the IEEE-488 STD bus, this manual pre-supposes a user knowledge of both ASCII data and IEEE-488 bus commands.

The 2100A implements the following IEEE-488-1978 standard subsets: SH1, AH1, T6, L4, SR1, RL1, PP1, DC1, DT1, C0, E1.

3.2 PRELIMINARY PROGRAMMING INFORMATION

3.2.1 GPIB Primary Bus Address and ASCII Line Termination Code(s)

The GPIB primary address and software-line-termination-character-sequence selection is set via the front panel keyboard as listed in tables 3.1 and 3.2. These two parameters are stored in non-volatile memory, therefore the instrument will remember them indefinitely even when the power is disconnected. They do not need to be re-entered each time the instrument is turned on.

The line-termination-character-sequence affects the GPIB in the TALKER mode only (data output from the 2100A to the GPIB). After the printable characters have been sent, non-printable characters, such as carriage return (abbreviated:CR) and line feed (LF), are often required for various computers. Table 3.2 lists the various key sequences with the line-termination-character-sequence it selects.

TABLE 3.1 SETTING AND DISPLAYING THE GPIB PRIMARY ADDRESS

To set a primary address from 00 to 30: [#][SECOND FUNCTION][BUS ADDRESS]
To display the primary address: [SECOND FUNCTION][BUS ADDRESS]

TABLE 3.2 LINE-TERMINATION-CHARACTER-SEQUENCE

Line-Termination-Character-Sequence	Key Board Entry
None	[0][SECOND FUNCTION][.]
Carriage return	[1][SECOND FUNCTION][.]

Line-Termination-Character-Sequence	Key Board Entry
Line feed	[2][SECOND FUNCTION][.]
Carriage return followed by line feed	[3][SECOND FUNCTION][.]
Line feed followed by a carriage return	[4][SECOND FUNCTION][.]
Display present line-termination-character-sequence selection	[SECOND FUNCTION][.]

3.2.2 IEEE-488 Bus Interface Programming Connector

The rear panel programming connector, labeled "IEEE-488 PORT" (Figure 5), is the standard bus interface connector as specified in the IEEE-488 STD. The connector uses metric hardware.

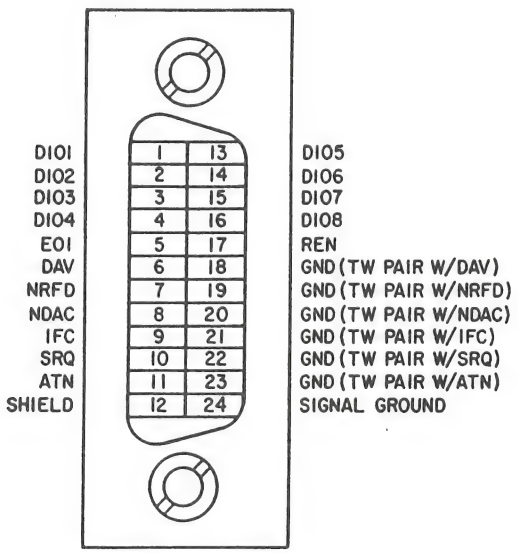


Figure 5. Rear Panel GPIB Connector

3.3 ASCII DATA COMMANDS

3.3.1 Format

The 2100A employs free-format software commands, allowing the user to program a specific function in several different ways. See Section 3.3.3.

3.3.2 Types Of Data Commands

A. Commands fall into two types: Those involving numeric parameters and those that do not.

Commands which involve a numeric parameter contain 3 types of fields:

1. Numeric: Numeric fields may be floating point or scientific notation:

   1 = 1.0
   1.0 = 1.0
   2.7E3 = $2.7X10^{3}$
   -2E3 = $-2X10^{3}$
   2E-3 = $2X10^{-3}$

2. Units: Units (i.e. Hertz, volts, seconds, etc.) are optional. A given parameter has a default unit, also a given unit has a default parameter (i.e. amplitude implies volts and volts implies amplitude, although dc offset is also expressed in volts).

3. Parameter: Parameter (frequency, amplitude, etc.) is included in Section 3.3.3.

B. Delimiters which may separate commands are: ":" , ";" and "\"

C. Two consecutive character strings (i.e. units, parameters, commands) must have a space between them or they will be treated as one string. No spaces are allowed within a units code, a parameter or a command code. Several commands may be represented by a non-alphanumeric character. No space is required before or after these characters.

D. The 2100A uses an internal 40 character buffer for command processing. A line may be composed of multiple commands, separated by the delimiters mentioned above. No commands are executed until the line is terminated with a ASCII line feed character (Hex 0A), an ASCII carriage return (Hex 0D) or by sending the end-or-identify (EOI) command with the last character.

3.3.3 Table Of ASCII Data Commands

In Section 3.3.3 the characters which are underlined must be sent for the command to be recognized properly. Additional characters may be sent once all the capitalized letters are sent.

Example: MVP: "MV" is underlined and must be sent for the command to be recognized. "P" is not underlined and need only be sent if it is desired to send additional characters for readability.

Note: In this table, the character "Ø" is an optional blank space used after a single character command, however, this blank is not re-quired if the letter is followed immediately by a delimiter (: ; or \).

Command Desired	Allowable Character Strings
WAVEFORMS:	
Sinewave	W1
Triangle wave	W2
Square wave	W3
Positive pulse	W4
Negative pulse	W5
Positive linear ramp	W6
Negative linear ramp	W7
Positive exponential ramp	W8
Negative exponential ramp	W9
+ Fixed offset on	X
- Fixed offset on	Y
± Fixed offset off	Z
MODES:	
Continuous mode	M1
Lin sweep	M2
Log sweep	M3
VC mode	M4
Gated mode	M5
Triggered burst mode	M6
Triggered pulse mode	M7
Manual trigger (trigger mode)/ Gate on (gate mode)	TR
Gate off (gate mode)	UN
OUTPUT CONTROLS:	
Volts peak	VO, VP
Volts rms	VR, R
Volts DC offset	VD
Millivolts peak	MVP
Millivolts rms	MVR
Millivolts DC offset	MVD
Microvolts peak	UV
Microvolts rms	UR
Microvolts DC offset	UD
PARAMETERS:	
Frequency (set and/or display hertz)	F
Hertz (frequency)	HZ
Kilohertz (frequency)	KH, KI
Megahertz (frequency)	MH, ME
Millihertz (frequency)	MI

Command Desired	Allowable Character Strings
PARAMETERS (cont):	
Microseconds (pulse width)	U0
Milliseconds (pulse width)	MS
Pulse width (set and/or display seconds)	P
Seconds (Pulse width)	S0
Microseconds (Pulse width)	US
Nanoseconds (Pulse width)	NS
Cycles/Burst (set and/or display)	B
Set phase (set and/or display start phase)	SE
Start phase (-90°)	ST1
Start phase (0°)	ST2
Start phase (+90°)	ST3
Variable start phase (Set degrees)	ST4
Sweep time (set and/or display seconds)	@
Sweep start frequency (set and/or display)	(
Sweep stop frequency (set and/or display)	)
"△" value (set and/or display)	#
Add △	&
Subtract △	%
"n" value (set and/or display)	N0
Multiply by "n"	*
Divide by "n"	/
MEMORY CONTROL:	
Clear memory	CL
GO TO command (store)	G, BR
Store next location	!, STO
Delete memory step	DEL
Recall (present step)	RC, ?
MISCELLANEOUS:	
Move intensified digit RIGHT	>
Move intensified digit LEFT	<
Increment intensified digit	I
Decrement intensified digit	DEC
Intensify LEFT most digit	DS1
Intensify 2nd digit	DS2
Intensify 3rd digit	DS3
Intensify 4th digit	DS4
Intensify 5th digit	DS5
Intensify 6th digit	DS6
Intensify RIGHT most digit	DS7
Clear entry	CE
Display serial number	SN
Self-Calibration	SC
Set "STATUS" as Talker output[1]	STS

Command Desired	Allowable Character Strings
MISCELLANEOUS (cont):P	
Service request on[2]	SRQON
Service request off[2]	SRQOF
Line termination codes[3]	
None	TE0
CR	TE1
LF	TE2
CR, LF	TE3
LF, CR	TE4
display selected code(s)	TE
No tone	TO1
Error tone	TO2
Full tone	TO3
Display software version	VE
Display hours of operation	HO

NOTES: 1 See Section 3.5.5.
2 See Section 3.4.2, "Service Request and Serial Polling".
3 See Section 3.2.1 and Table 3.2.

3.4 IEEE-488 STANDARD COMMANDS

These commands are sent with ATN true as described in the Standard.

3.4.1 Multi-Line Messages

IEEE-488 COMMAND	MNEMONIC	RESULT
My Listen Address	MLA	Enables unit to receive data.
Unlisten	UNL	Disables all units from receiving data.
My Talk Address	MTA	Designates unit to send data.
Untalk	UNT	Disables all units from sending data.
Local lockout	LLO	Disables return to local key (CE key) on front panel such that when in remote mode, keyboard cannot be activated by the keyboard.
Go To Local	GTL	Puts unit into local control mode such that front panel keyboard is activated.
Device Clear	DCL	Executes a [CLEAR MEM] command. Operates the same as the front panel command. See Section 2.4.5.1.
Selected Device Clear	SDC	Performs same functions as Device Clear (DCL) except only if unit is addressed as a listener.
Group Execute Trigger	GET	If unit is addressed, this command provides a trigger pulse to generator (equivalent to pressing manual trig on front panel).

Discussion:

(See section 2.8 and Figure 10 of the IEEE-488 Interface Standard). Note that there are 4 possible states; local, remote, local-with-lockout and remote-with-lockout. Front panel control is considered to be local, while control from the system controller is considered to be remote. Selection of local or local-with-lockout and remote or remote-with-lockout is done several ways. When the unit is addressed to talk (MTA) or listen (MLA), it goes into remote. When Go To Local (GTL) is sent, it goes into local mode or local-with-lockout mode.

Also, if lockout mode is not invoked by the controller (local lockout command LLO), pressing the [CE] key when the REMOTE LED is on will return control to the keyboard.

Note: The lockout mode is not related to whether control is local or remote, only whether control can be returned to local by the [CE] key.

Lockout mode (local-with-lockout and remote-with-lockout versus local and remote) is controlled by the controller. Sending the Local lockout command (LLO) selects the local-with-lockout and remote-with-lockout pair versus remote and local without lockout out. Lockout can only be canceled by the controller placing the remote enable line false.

3.4.2 Polling Commands

The IEEE standard provides two methods of determining the status of the devices in the system; namely serial poll and parallel poll. The parallel poll produces up to 8 bits of status from up to 8 different units simultaneously. A parallel poll is very fast but provides limited information. The serial poll provides 7 bits of status from one unit at a time.

PARALLEL POLLING

The Model 2100A provides for software configuring of which bit and with which polarity the unit should respond. This bit is "true" when an error condition exists.

Configuring needs to be done only once or anytime the software desires to change the configuration. The commands related to parallel poll are as follows:

For sample sequences, see section 6.5.4 of the IEEE-488 standard.

IEEE-488 COMMAND	MNEMONIC	RESULT
Configure	PPC	Places unit into a state where it expects parallel poll enable and disable commands to establish which bits should be set or selected in response to a parallel poll.

IEEE-488 COMMAND	MNEMONIC	RESULT
Unconfigure	PPU	Removes unit from PPC state (UNL does the same thing but also unlistens device).
Enable	PPE	When unit is in PPC state, it indicates which bit and which polarity the device should respond. Hex codes 60-67 selects bits 0-7 respectively to be set to 0 for a true error response. Since logic 0 is HI on open collector lines, this provides a logical "OR" of all units designated to respond with given line. Hex codes 68-6F selects bits 0-7 respectively to be set to 1 for a true (error) response. This can provide logical NAND of all units designated to respond with a given line.
Disable	PPD	Clears any configuration previously entered. This is valid only when unit is in PPC state.

Example:

If the 2100A to be configured is unit #5, and we want it to respond with a "1" when an error exists;

IEEE-488 COMMAND	RESULT
MLA 5	Addresses unit to be configured.
PPC PPE 8	Places unit into parallel poll configured mode. Configures bit #0 (Lo 3 bits of command) to respond with a "1" (8's bit) when an error exists.
UNL	Unlistens unit.

For additional sample sequences, see section 6.5.4 of the Standard.

SERVICE REQUEST AND SERIAL POLLING

The IEEE-488 standard provides serial polling as a method of determining which unit caused a service request. When serial poll enable (SPE) is sent, the system goes into serial poll state. When a unit is addressed to talk, a single status byte will be sent. The hex 40 bit in this byte is true if that unit is requesting service. The remaining bits are used to provide status information. The 2100A service request capability is enabled or disabled with the SRQON and SRQOFF commands (see Section 3.3.3). The unit turns on with service request disabled. This is an extension of the standard.

IEEE-488 COMMAND	MNEMONIC	RESULT
Enable	SPE	Unit enters serial poll when a unit is addressed to talk. It will send one status byte in which the hex 40 bit is true if the unit is requesting service.
Disable	SPD	Unit exits serial poll state.

SERIAL RESPONSES

The chart below lists the error numbers, in decimal notation, resulting from a command error either from the bus or not from the bus.

The serial responses are:
1. No error; 0.
2. Error (error numbers in decimal notation); See the chart at the bottom of the page.

Note: If SRQ is "ON" and the command which caused the error came from the bus, not the front panel, then the hex 40 (decimal 64) bit will be sent in the serial poll response, indicating that this unit requires service.

PARAMETER	LOWER LIMIT EXCEEDED	UPPER LIMIT EXCEEDED
Frequency	32	48
Pulse width	33	49
Sweep start frequency	34	50
Sweep stop frequency	35	51
Sweep time	36	52
AC peak	37	53
AC rms	38	54
Variable dc offset	39	55
Cycles/burst	40	56
Gate/triggered phase	41	57
n	42	58
△	43	59

MESSAGE	ERROR CODE
LO Entry	1
HI Entry	2
HI Pulse	5
Delete error	6
End store	9
End recall	10
Storage full	11
GO TO error	15

MESSAGE	ERROR CODE
PLL 1 error	16
PLL 2 error	17
PLL 3 error	18
PLL 4 error	19
No data	20

3.4.3 Uniline Messages

IEEE-488 COMMAND	MNEMONIC	RESULT
End	END	Sent with last byte of data. A line of data may either be terminated by a line feed character or by this command.
Identify	IDY	This command, issued by the controller, causes a parallel response which was previously configured by the PPC, PPD, PPE and PPU commands.
Request service	RQS	Generated in response to an error when the command came from the bus, and service request is enabled by the SRQON command.
Remote enable	REN	When true, allows the 2100A to respond to remote messages. When this line goes false, the unit will go to local-without-lockout state, activating the front panel.
Interface clear	IFC	Un-addresses all units and clears all special states.

3.5 TALKER FORMAT

The Talker function allows an IEEE-488 (GPIB) controller to interrogate the Model 2100A and read back over the bus it's settings (waveforms, modes, parameter values, etc.).

Two different types of data can be sent over the bus: parameter information and status information.

3.5.1 Parameter Information

If the last ASCII command sent to the 2100A was not "STS", then the 2100A talks what is in the display such as: "1.000000 E+3 FREQ". The displayed parameter can be selected either over the bus or from the front panel by sending the code for the parameter or pressing the key(s) respectively.

3.5.2 Numeric Format

The exact format in which the number is sent follows:

1. "-" or digit followed by an optional decimal point *.
2. Digit followed by an optional decimal point *.
3. Digit followed by an optional decimal point *.
4. Digit followed by an optional decimal point *.
5. Digit followed by an optional decimal point *.
6. Digit followed by an optional decimal point *.
7. Digit followed by an optional decimal point *.
8. Space.
9. One of: E±6, E±3, E±0, E-3, E-6 or E-9.
10. Space.

* only one of the 7 optional decimal points is sent.

The following are examples of this format:

1.0000000ßE+3ß
-2.00ßßßßE+0ß

3.5.3 Parameter String Format

Following the number, an ASCII string indicates which parameter is displayed.

The basic parameter codes are:

FREQ	: frequency
AC PEAK	: ac peak voltage
AC RMS	: ac rms voltage
DC OFFSET	: dc offset
PULSE WIDTH	: pulse width
START	: sweep start frequency
STOP	: sweep stop frequency
TIME	: sweep time

The end of the string is terminated with some combination of ASCII <CR>, <LF> and the GPIB EOI, depending on the user's selection (see Table 3.2). The IEEE-488 EOI line is always set true concurrent with the last character.

3.5.4 Error Conditions And Advising Messages

When a message is displayed on the 2100A, the GPIB will return that message when addressed to talk.

3.5.5 Status

Status is obtained by the controller sending the ASCII command STS, then addressing the unit to talk. The unit will send a string of four numbers (ASCII characters), followed by the line-termination-character-sequence which the user selected (see Table 3.2).

Each number indicates a status or mode condition as follows:

Digit Position	Number	Meaning
1 Waveform	1	sinewave
	2	triangle
	3	squarewave
	4	positive pulse
	5	negative pulse
	6	positive ramp
	7	negative ramp
	8	positive exponential ramp
	9	negative exponential ramp
2 Fixed Offset	0	none
	1	+ fixed offset
	2	- fixed offset
3 Mode	1	continuous
	2	linear sweep
	3	logarithmic sweep
	4	external VC
	5	gate
	6	triggered burst
	7	triggered pulse
4 Start Phase	1	-90°
	2	0°
	3	+90°
	4	user entered start phase

After sending the status, the effect of the STS command is canceled and the unit will send numeric information as described in Section 3.5.5.

SECTION 4

INCOMING ACCEPTANCE AND ROUTINE PERFORMANCE TESTS

4.1 INTRODUCTION

The following procedure may be used to verify the 2100's performance specifications both for incoming acceptance and for routine servicing. All tests should be made with the covers in place and secured.

4.2 EQUIPMENT REQUIRED

The following instruments are required to test the Model 2100 properly:

1. OSCILLOSCOPE: bandwidth from dc to 100MHz, vertical sensitivity 5mV/cm, ac/dc coupled, Tektronix Model 2235 or equivalent.

2. FREQUENCY COUNTER: capable of measuring frequency or period fron .001Hz to 50MHz, 8 digit display, accuracy of 0.01ppm. HP Model 5316A with oven time base or equivalent.

3. TRUE RMS VOLTMETER: accuracy of 0.05% at 1kHz. Fluke Model 8920A or equivalent.

4. DC VOLTMETER: zero to 100V input, 1mV resolution. Fluke Model 8000 or equivalent.

5. DISTORTION ANALYZER: bandwidth of at least 500kHz, capable of measuring total harmonic distortion down to 0.01% (-80dB) below 100kHz. Krohn-Hite Model 6900A or equivalent.

6. SPECTRUM ANALYZER: HP Model 141T Display Section; Model 8552B Spectrum Analyzer IF-Section; Model 8553B Spectrum Analyzer RF-Section or equivalent.

7. 50Ω ATTENUATOR: Tektronix Model 011-0059-02 or equivalent.

4.3 PERFORMANCE TESTS

Follow the turn-on procedure in Section 2 (page 2-1). After the Self-Test feature has verified that the microprocessor circuitry is functioning normally, the 2100 should be allowed to warm-up for at least 30 minutes before proceeding with the tests.

4.3.1 FREQUENCY ACCURACY CHECK

This test is for standard reference only, "Non-Ovenized".
Connect frequency counter to TTL Output. Use external working standard time base for counter if internal time base is less accurate than 0.05ppm.
Set frequency for 30MHz.
Counter should read 30MHz ±15Hz.
If necessary, allow counter to overflow to get enough resolution.

4.3.2 DISTORTION CHECK

Connect Distortion Analyzer to the Main Output.
Set the Waveform to sinewave.
Set Main Output to 15V AC Peak.
Measure the distortion at the following settings:

Frequency	Tolerance
20Hz	0.05%
200Hz	0.05%
2kHz	0.05%
5kHz	0.05%
10kHz	0.1%
15kHz	0.1%
20kHz	0.25%
30kHz	0.25%
100kHz	0.25%
300kHz	0.5%
500kHz	0.5%

4.3.3 AMPLITUDE CALIBRATION CHECK

With the generator set for 2kHz, sinewave, measure the output amplitude with the True RMS Voltmeter at the following places:

AC Peak Setting	RMS Reading	Tolerance
15V	10.61V	±1%
10V	7.07V	±1%
5V	3.54V	±1%
2V	1.414V	±1%

Set amplitude for 10.00V peak.
Set True RMS Voltmeter for dB and relative operation.
Set Xn/÷n for 10.
Divide amplitude by n.
True RMS Voltmeter dB reading should be -20dB ±.1dB.
Reset dB relative reading.
Repeat above starting with divide amplitude by n. Due this twice.

4.3.4 DC OFFSET CHECK

Set peak amplitude to 0V.
Connect DVM set for DC to Main Output.
Measure offset at the following settings:

Offset Setting	Tolerance
+.1V	±.001V
+.3V	±.01V
+.7V	±.01V
+1.5V	±.1V
+3.0V	±.1V
+6.0V	±.1V
+12.7V	±.1V

4.3.5 SQUAREWAVE RISE TIME CHECK.

Connect Main Output to scope with 50 ohm terminator and 50 ohm cable.
Set DC offset to zero "0".
Set frequency to 2.5MHz.
Set waveform to squarewave.
Set amplitude to 10V peak.
Set scope time base to .05µSec x 10 mag.
Observe squarewave rise and fall time is less than 11nSec (2.2cm) between 10% and 90% points.
Set frequency to 10kHz.
Observe squarewave flatness on scope with a 6cm display less than .2cm droop or rise.

4.3.6 SPECTRUM ANALYZER CHECK

WARNING!

Blow-Out of the Analyzer's input can occur with signals greater than 1.4V peak and/or 50Vdc. To prevent this from happening, always use a 20dB feed through attenuator on its input BNC as a precaution against the full output of the 2100.

Do not connect an unknown signal to its input; first set the 2100 output for 0 DC OFFSET, sinewave, and 1.00V peak amplitude.

Set the Spectrum Analyzer to the following:

Input attenuator for 10dB.
I.F. Log Ref Level for -20dBm on black scale (-40dBV on red scale).
Bandwidth for .3kHz.
Scan Width for 5kHz.
Tuning stabilizer ON.
Scan time .1sec.
Center frequency tuning to 30MHz.
Connect 2100 Main Output to Analyzer input through 20dB feed through attenuator.
Increase Scan Width and adjust Center Frequency Tuning to find signal. This will be required for all frequency settings.
Reset Scan Width for 5kHz.
Adjust Analyzer I.F. gain for full scale, just touching the 0dB line.

Measure the noise and the spurs at the following frequency settings:

Frequency	Noise	Spurs
30MHz	-35dB	-30dB
10MHz	-35dB	-30dB
5MHz	-35dB	-30dB
3MHz	-55dB	-50dB
400kHz	-55dB	-50dB
100kHz	-60dB	-50dB

SECTION 5

CIRCUIT DESCRIPTION

5.1 INTRODUCTION

This section describes the overall operation of the Model 2100. A simplified block diagram is shown in Figure 5.1.

5.2 OVERALL SYSTEM DESCRIPTION

The 2100 is made-up of two main generating systems, (Refer to Figure 1). First, is the High Frequency Waveform Synthesizer which develops the output waveforms over the frequency range of 30kHz to 31.16MHz. It consists of multiple Phase Lock Loops (PLL's) developing up to seven digits of frequency resolution locked to the reference. Second, is the Read Only Memory or ROM Waveform Synthesizer which develops the waveforms below 30kHz. It consists of a ROM lookup table containing waveform data, which feeds a 12-bit high speed DAC. Tied into this circuit is the gate trigger control logic. The ROM circuit addressing is clocked by the High Frequency Waveform Synthesizer to step through the data and generate a waveform at the DAC output. Each cycle of the waveform is made up of 250 data points. This circuit is set up to behave as a divide by 1000 or divide by 1,000,000, dividing the High Frequency Waveform output down, generating frequencies from .03Hz to 30kHz, with full 6 or 7 digit resolution locked to the reference. Generating low frequency sine waves with this method produces high spectral purity with very little jitter, low harmonic content, low spurious content and fast settling time.

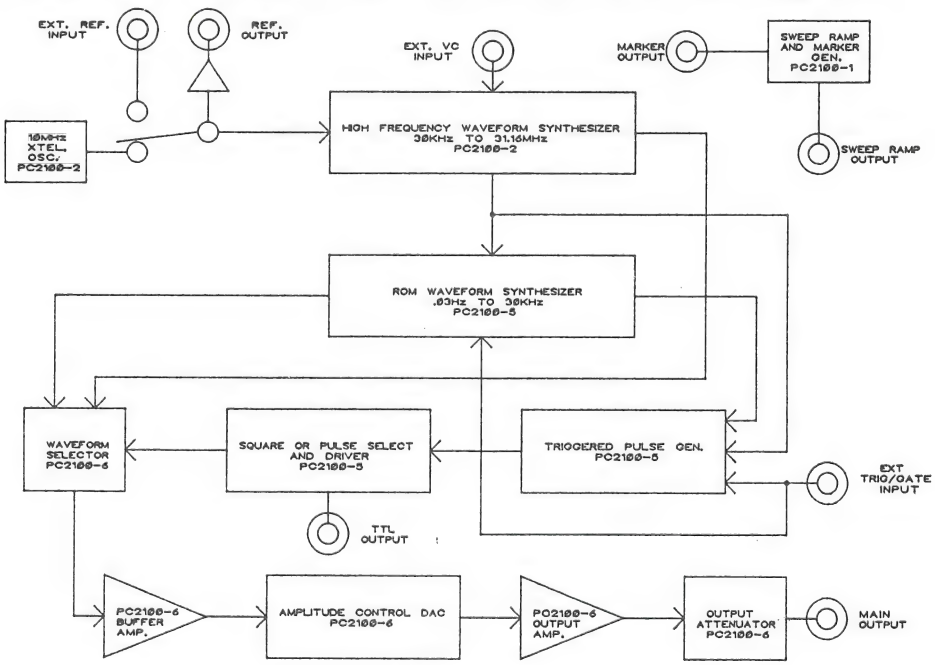


Figure 5.1

Along with these two main generators are two additional generators. One is the Triggered Pulse Generator, which generates a pulse of set duration each time its triggered. This generator can be triggered internally or externally. The other generator is the Sweep Ramp and Marker Generator. This generator produces the Ramp and Marker outputs synchronous with the Sweep Frequency function.

The High Frequency (above 30kHz) and Low Frequency (below 30kHz) waveforms are fed to the Main Output Waveform Selector. The Pulse or Square waveforms feed a driver circuit which in turn feeds the Main Output Waveform Selector. The selected waveform feeds a buffer amplifier which drives the 11-bit Amplitude Control DAC. It in turn feeds the Main Output Amplifier which drives the Main Output through the output attenuators.

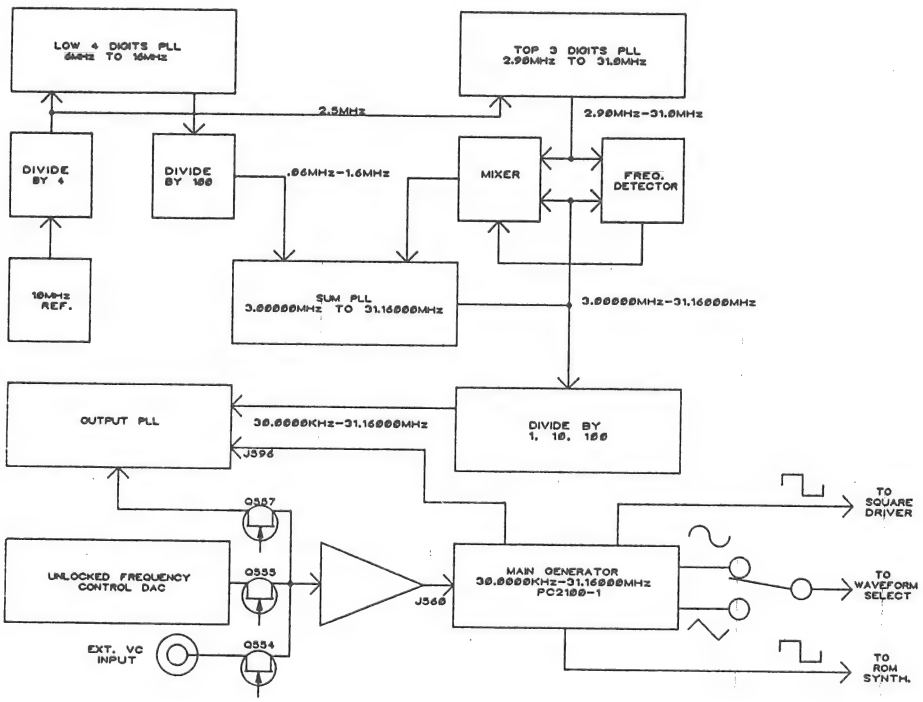


Figure 5.2

5.3 HIGH FREQUENCY WAVEFORM SYNTHESIZER

Four Phase Lock Loops make up the High Frequency Waveform Synthesizer (refer to Figure 5.2). Three of them combine to generate frequencies from 3MHz to 31.16MHz. The fourth uses the Main Generator (a high performance function generator) as its VCO and provides the high frequency sine, triangle waveforms and squarewave drive for clocking the ROM synthesizer. This Main Generator PLL, called the Output PLL on the schematic, is locked to the 3MHz to 31.16MHz signal divided by 1, 10 or 100. This provides frequency coverage from 30kHz up to 31.16MHz.

The Low Four Digit PLL provides the low four digits of resolution in the final output. It's output is combined with the Top Three Digits PLL output in the Sum PLL to produce up to seven digits of resolution in the final output. The

output of the Sum PLL feeds the 1, 10 or 100 divider chain which feeds the Output PLL. The Main Generator functions as the VCO of Output PLL only in the locked modes, which are Continuous, Gate and Trig Burst. In the unlocked modes, Lin/Log Sweep and VC, the Main Generator frequency is set by the Unlocked Frequency Control DAC. The data necessary for the DAC is derived from a calibration table (in non-volatile memory) generated when a Self-Calibration is executed. When Self-Calibration is called, the Main Generator PLL phase detector is converted to a frequency detector. The Microprocessor sequences the 2100 through a number of frequencies. For each frequency it increments the Main Generator through the DAC until the correct frequency is reached, then the DAC setting necessary is stored in a table.

The Sum PLL uses a mixer in its frequency feedback to add the Top Three Digit PLL output into the Sum PLL output. It does this by using the difference frequency, between the two, at the mixer output. In normal operation the Sum PLL output should be higher in frequency by the amount of the output frequency from the Low Four Digit output divided by 100. A stable lock can also occur if the Sum PLL output is lower by the same amount. The mixer only sees the difference, not which one is higher. To prevent this condition, a frequency detector disables the mixer action if the wrong condition is detected, forcing the the Sum PLL frequency up to correctly lock.

5.4 MAIN GENERATOR

The Main Generator is functionally equivalent to a high performance Function Generator operating over the frequency range of 30kHz to 31.16MHz in three decade ranges.

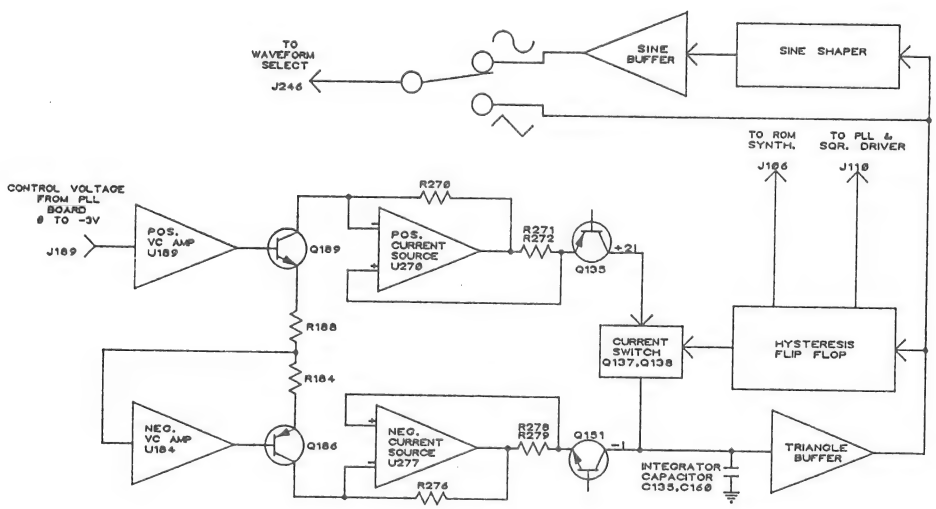


Figure 5.3

Referring to Figure 5.3, the control voltage of 0 to -3 volts from the PLL board feeds the Positive Voltage Control Amplifier U189, it's output on the emitter of Q188 feeds the negative VC Amplifier through R188. The VC output voltages developed on the emitters of Q186 and Q188 are equal and opposite and produce a current which is passed on through their collectors to the positive and Negative Current Sources U270 and U277 respectively. These current sources invert the direction of the current fed them and scale the value with resistors R271 or R272 for the Positive source and R278 or R279 for the negative. The larger values are used on the lowest range covering 30kHz to 311.6kHz, the smaller values are switched in for the next two higher ranges. The resistor used for the positive source is one half the value used in the negative source, resulting in twice the current output as compared to the negative source. The Negative Current Source output is called -I and the Positive Current Source output is called +2I. The currents are fed to the emitters of Q151 for -I and Q135 for +2I and pass on to there collectors. These transistors function to isolate the current source outputs from the fast signal voltages that are present on there collectors. The -I feeds the Integrating capacitor directly causing it to produce a negative going ramp of voltage. The +2I feeds the emitters of Q136 and Q137 a differential pair running as a current mode switch. This pair can switch the +2I either to ground or to the integrating capacitor. When its to ground we get a negative ramp, when its to the capacitor we get a positive going ramp of voltage. The current mode switch is driven by the Hysteresis Flip-Flop which detects the buffered voltage from the Integrator capacitor (Triangle Buffer output) and flips each time it reaches +1.5 or -1.5 volts. The drive to the current switch is such as to reverse the direction of the ramp at the 1.5 volt points resulting in a 3 volt peak to peak triangle centered about ground at the Triangle Buffer output.

A Sine Shaper is used to shape the triangle into a sine waveform. (Refer to the schematic) It consists of five differential pairs connected in parallel (Transistor arrays U205,U215 and U225). Each pair is biased from current sources of differing values. Each pair's gain is set by emitter resistors again with differing values. The triangle is fed single ended to each pair and the output taken off single ended from there common connected collectors. The shaping action occurs by progressively driving each pair to current clipping. The bias current for each pair is insufficient for linear operation over the full triangle amplitude. As each pair clip its contribution to the output is removed reducing the output waveform slope in a progressive manner. The component values are so chosen as to produce a piece wise linear approximation of a sine waveform. This shaper output is sitting at +5.5 volts above ground and requires a buffer amplifier to level shift it before feeding it to the output selector.

The above 30kHz sine or triangle is selected to be fed to the Main Output Waveform Selector. The Hysteresis Flip-Flop provides drive signals for the Output PLL phase detector, Squarewave driver and ROM Synthesizer.

5.5 ROM WAVEFORM SYNTHESIZER PC2100-5

Waveforms produced in the ROM Waveform Synthesizer are made up of 250 data points per cycle (refer to Figure 5.4). The data for each point is stored in three ROMS, U856, U860 and U861. A 12 Bit binary number represents the magnitude at each point in time. It requires 10 Bits of binary address to access each data point. Two Bits select memory blocks containing the sine, triangle, linear ramp or exponential ramp waveform data. The other 8 Bits select each data point. These 8 Bits are generated by clocking two pre-settable 4 Bit counters set up to count from 6 to 256 allowing 250 points to be addressed. The rate at which the counters are clocked determines the resultant waveforms frequency. The counters clock rate must be 250 times the wanted output frequency. The counters act as a divide by 250 to their input. The High Frequency waveform generator can cover 30kHz to 31.16MHz. This is a 1000 to 1 range. To cover the next lower 1000 to 1 range the ROM Synthesizer must divide by 1000. The address counters divide by 250 so an additional divide by 4 is provided by the pre-scaler U850. To further cover the next 1000 to 1 range down the ROM Synthesizer must divide by 1,000,000. This requires an additional divide by 4000 provided by U850 set for divide by 16 and U852 and U853 set for divide by 250.

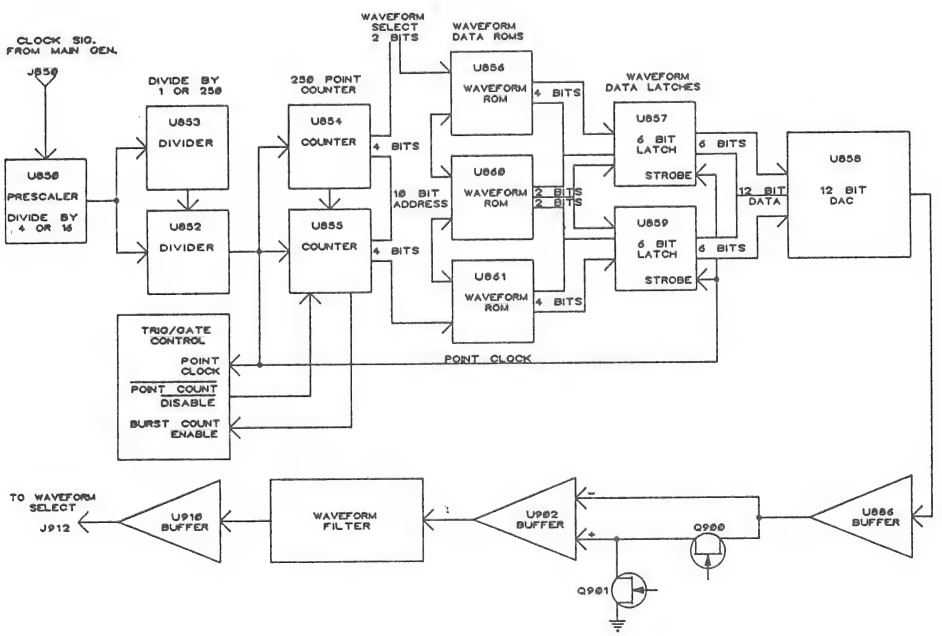


Figure 5.4

All 12 Bits of data entering the waveform DAC should arrive in unison (altogether) and hold for the period of one clock point. To force this condition, the ROM's data output is latched in two 6 Bit latches, U857 and U859. The point clock signal is used to strobe these latches. The current output of the DAC is converted to a waveform voltage through buffer amplifier. U886. This signal feeds the invert select switching, Q900 and Q901, which

feeds another buffer amplifier U902. To improve the sine waveform a filter is used to remove the 250th harmonic produced by each data step. The signal out of the filter is buffered once again and then fed to the Main Waveform Selector.

5.6 TRIG/GATE CONTROL PC2100-5

The ROM Synthesizer waveforms can be gated on and off with settable start-stop point, without loss of precision frequency. This is done by inhibiting the Point Address Counters from counting the point clock. The inherent frequency precision is in the point clock which doesn't stop. The Point Address Count Disable line is pulled low to stop the count.

Referring to Figure 5.5, the circuits which perform this control consists of two very similar pre-settable counters. The Burst Cycle Counter U874 and U877, counts the number of cycles for Triggered Burst mode. The Hold Point Counter U875 and U876, counts data points, selecting the point to inhibit the Point Address Counters stopping the waveform.

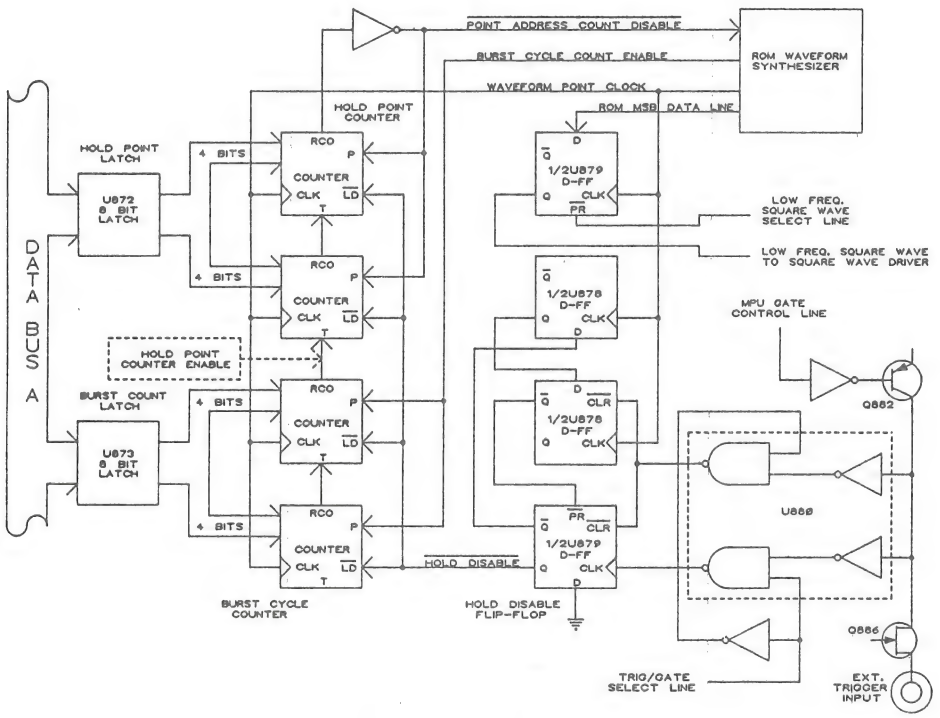


Figure 5.5

In the triggered burst mode Q886 is turned on and the MPU Control Line is set low, turning Q882 off. This allows the External Trigger Input to feed U880's input. IC U880 functions as a dual output sense amplifier. The output, which is active, is selected through the Trig/Gate Select Line. A high state on this line selects the trig control output. This output feeds the clock input to a D type Flip-Flop, 1/2 U879. The Flip-Flop "Q" output is the Hold Disable Line which feeds the load inputs to the Burst and Hold Point Counters. When

this line is set low by the rising edge of the External Trigger Input, two things happen. First data representing the hold point and burst count in latches U872 and U873 is loaded into there respective counters pre-setting them. Simultaneously the RCO line out of the counters goes low forcing the Point Address Count Disable line high allowing the Point Address Counters to start counting and resume waveform generation. The Hold Disable Line must be reset high in order for the Burst and Hold Counters to count once the Point Address Counters are running. This is done through two additional D type Flip-Flops, U878. These two Flip-Flops are clocked synchronously with the waveform point clock signal and are set up to require two clock cycles to ripple through and drive the Hold Disable Flip-Flop preset input low, resetting it's Q output high (Hold Disable line high) enabling the Burst and Hold Counters. Two clock cycles are used to insure that the counters are preset and waveform generation started on every input trigger. If only one clock cycle were used, depending on relative timing between the trigger and point clock pulse, the set reset of the Hold Flip-Flop could occur so rapidly that the trigger would not start waveform generation.

The Burst Cycle Counters range of count is from 1 cycle to 255 cycles. To count 1 cycle the counter is preset or loaded with 254. To count 255 cycles it is loaded with 0. It counts one waveform point clock each time the Point Address Counters RCO (Burst Cycle Count Enable) line goes high indicating the completion of each full waveform cycle of 250 points. Starting from there preset value, when the Burst Counters complete there count to 255 (preset + cycles = 255) it's RCO (Hold Point Counter Enable) line goes high enabling the Hold Point Counters to start counting waveform point clocks. Similarly the Hold Point Counters start at the preset point and count until 255 is reached (preset + point clock cycles = 255), at which time it's RCO output goes high forcing the Point Address Count Disable line low stopping the Point Address Counters and waveform generation at that point.

The above description describes one triggered burst. The whole operation will repeat on the next rising slope of the External Trigger input.

The Gate mode operates the same as Triggered Burst except for the following. First, the Trig/Gate Select Line is set low allowing the Gate Control output of U880 to control the Hold Disable Flip-Flop through it's CLR input. This forces the Hold Disable Q output to stay low as long as the CLR input is low, allowing waveform generation. When the External Trigger Input drives the CLR input of the Hold Flip-Flop high, only one waveform clock is needed to reset the Hold Disable line high and enable the Burst Cycle Counters. In the Burst mode the Burst Cycle Counters are set to count one last cycle before enabling the Hold Point Counters and stopping the waveform.

Continuous operation is the same as Gate mode except Q886 is turned off and the MPU Gate Control Select Line is set high turning Q882 on. This forces the unit to stay gated on.

One of the D Flip-Flops in U879 is used to provide a synchronous low frequency (below 30KHz) square waveform for the Square Wave Driver. The Most Significant Bit (MSB) from the waveform data ROMs is fed to the D input of the Flip-Flop. The waveform point clock drives the clock input. When the Low Frequency Square Wave Select Line is set high, a synchronous squarewave is produced on the Q output and fed to the Square Wave Driver circuit.

5.7 PULSE GENERATOR PC2100-(1 and 5)

The Pulse Generator consists of two basic parts (refer to Figure 5.6). A precision timing circuit which sets the pulse width and a triggered D Flip-Flop to start the timer and reset it at the end of the pulse timing cycle.

A ramp, generated by charging a timing capacitor with a controllable current source, does the timing. The current source is made up of U300, U304, U327, Q1029 and Q1030. FET Q1027 along with Q1026, Q1025 and Q1021 form a sense amplifier to detect the ramp voltage on the timing capacitor. When that voltage reaches approximately 2.9 volts the sense amplifier resets the Flip-Flop (1/2 U1009) through it's CLR2 input.

To select pulse output the Pulse Enable line is set high. When a rising edge from the trigger signal on U1009's CLK2 input triggers the Flip-Flop, it's Q2 output goes high shutting off reset transistor Q1028. This allows a timing ramp to begin. When the ramp reaches 2.9 volts the sense amplifier drives Q1021 on pulling the CLR2 input on the Flip-Flop low resetting the Q2 output low ending the pulse cycle. When the Q2 output goes low it drives the reset transistor Q1028 on, discharging the timing capacitor and holding it reset until the next trigger input to the Flip-Flop. The pulses produced on the the Q2 and Q2 outputs are fed to the second Flip-Flop in the package CLR1 and PRI1 inputs. This forces the second Flip-Flop to follow these outputs on its outputs, Q1 and Q1 and function as a buffer for the pulse out. FETs Q996 and Q997 select which pulse to send to the Driver circuit. The trigger input can come from three sources. The Main Generator for frequencies above 30KHz, the ROM MSD line for frequencies below 30KHz or the External Trig Input.

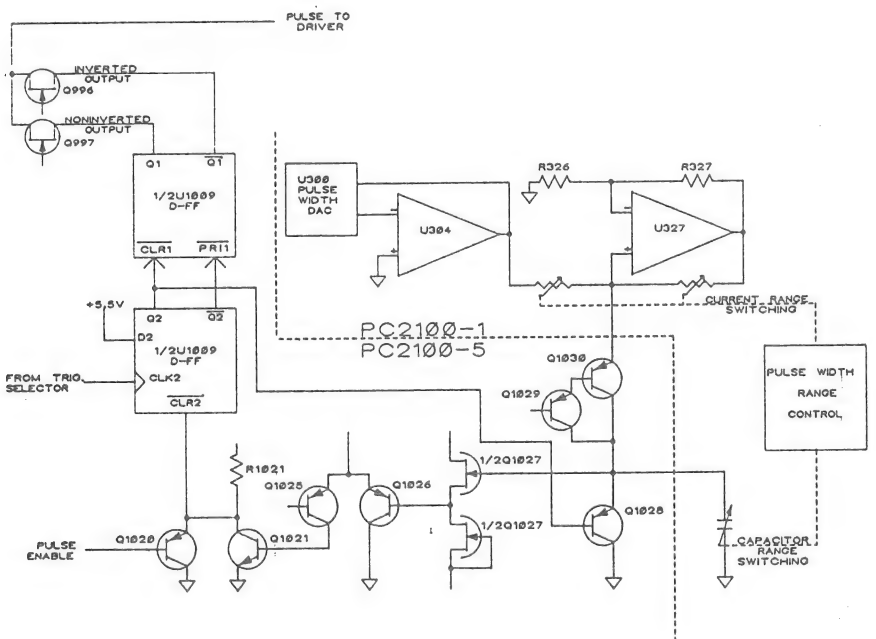


Figure 5.6

5.8 SQUARE AND PULSE DRIVER PC2100-5

Referring to schematic PC2100-5 Part 2, the Square and Pulse Driver circuit has two sections, an output section and a waveform source select section.

The output section consists of a current mode switch Q975 and Q977 which develop the clean fast rise time waveforms. The TTL output is on Q968's collector and the Main Output Waveform for the Output Selector on Q975's collector. The drive for this circuit comes through Q965, a common base transistor amplifier.

The emitter of Q965 can be driven from one of three sources. The emitter of Q956 for pulse waveforms, the emitter of Q950 for below 30KHz square waveforms generated by U879 and the collector of Q959 for above 30KHz square waveforms from the Main Generator. Each drive can be disabled as follows. The pulse drive is disabled by locking the pulse generator output high with a low state on it's Pulse Enable line. This holds Q956 off. Similarly, the below 30KHz squarewave is disabled by a low state on it's select line, locking it's output high which will hold Q950 off. The above 30KHz squarewave is disabled by holding the base of Q958 high, turning Q959 off and preventing it from driving Q965's emitter. Only one source of drive will be active at any time.

5.9 MAIN OUTPUT PC2100-6

Referring to schematic PC2100-6, three FETs, Q1064, Q1065 and Q1066 selects the source of signal for the Main Output. The selected signal is buffered by the Waveform Buffer Amplifier, and then fed to the Output Amplitude Control, an 11 Bit multiplying DAC. The output from the DAC feeds the gain of ten Output Amplifier. The Output Amplifier drives the Main Output through the dB Attenuators and output crowbar protection circuit.

The Waveform Buffer is a unity gain single stage differential feed back amplifier made up of transistor array U1085, transistor Q1088 running as a zener (base emitter junction) and emitter follower Q1091. The fixed offset function is implemented by halving the amplitude at the Buffers input and adding the necessary DC offset to the feed back point of the Buffer.

The Amplitude Control DAC consists of a resistor ladder network made up of 150 and 280 ohm resistors. Each section of the ladder can be switched between ground or the Buffer output by a pair of FETs. A push pull driver drives the FETS so when one is on the other is off. Latches U1102 and U1103 hold the amplitude data that controls the FETs.

The Output Amplifier is a two stage differential feed back amplifier set up for a gain of ten. The first stage is transistor array U1215. It drives the complementary second stage deferentially. The second stage is made up of Q1231 and Q1225. It's bias current is set up with a current source made up of Q1234 and Q1235. At higher frequency this current source is driven to increase the drive capability. The full output voltage swing is developed on the collectors of Q1225 and Q1235. This voltage then drives the parallel complementary push pull emitter followers Q1245, Q1246, Q1248 and Q1249. Fuses F1001 and F1002 are to prevent printed circuit board damage should a device short out. In such an event excessive power in 1/4 watt resistors could burn the board. The signal is fed to the plus input and the Variable DC Offset function feeds the negative input of the amplifier. An 8 Bit DAC, U1264 provides the offset control.

The dB Attenuator consists of a 40dB and 20dB pie sections. They are switched with relays K1270 and K1277.

Output protection is provided by sensing for abnormal currents in R1287 and triggering Triac Q1291 on, crowbaring the output to ground. This allows up to 50 Volts current limited to 1 Amp or fused for 2 Amps to be accidentally connected to the output.

5.10 POWER SUPPLY PC2100-7

Power for the 2100 is provided through seven regulated supplies. They are ±25, ±15, ±5.5 and +5 Volts. The ±15 and +5 Volt supplies use IC regulators. The ±25 and ±5.5 use discrete components with series pass transistors for enhanced performance.

The +25 supply contains a low TC reference zener. This supply provides the reference for the -25 Volts and +5.5 Volts through resistor dividers. The -25 provides the reference for the -5.5 Volts through a divider network. All three supplies (±5.5 and -25) will track the +25 supply.

The +25 supply consists of a series pass transistor Q1302, a driver transistor Q1303, driven by an op-amp U1308. The 6.4 Volt zener reference provides a fixed voltage to the op-amp non-inverting input. The inverting input is connected to the supply output through voltage divider R1315, R1316 and R1317. Resistor R1315 is adjusted for 50 Volts between the +25 and -25 supplies. This should bring them to within .2% of 25 Volts. The -25 supply is the same except for polarity and the reference provided through summing resistor R1318.

When one of the 25V supplies is shorted the op-amp receives no power and is unable to turn the driver transistor on, which in turn would not drive the series pass transistor on. This will limit the current to that provided by the shunt resistors across the pass transistors R1301 or R1310. In normal operation the shunts provide enough current to bring the supplies up to op-amp operation levels.

Zener VR1316 and diode CR1315 limits the +25V output until the -25 can get started. This prevents a lockup condition.

The +5.5V supply consists of a series pass transistor Q1343 driven by an op-amp U1345. The reference voltage is developed through voltage divider R1349 and R1355 from the +25V supply. Current limiting is provided by current sense resistors R1340 and R1341 and diodes CR1342, CR1343, CR1344 and CR1345.

The -5.5V supply is the same as the +5.5V supply except for polarities.

The +5 Volt IC regulator provides power for the microprocessor and front panel boards. To reduce voltage losses through ground drop, the ground sense connection to U1360 is made at the microprocessor board connector. If this board is disconnected the ground connection will be made through CR1360 resulting in a 0.6V increase in regulator output voltage.

5.11 MICROPROCESSOR PC2100-3

The MPU board provides the intelligence for inputting parameter settings and outputting control commands to the generator. Referring to schematic PC2100-3, It uses an MC68B02 8 Bit Microprocessor running with a 2MHz clock rate. The resident program is stored in three (four on earlier units) 2764D ROMs. Non-volatile RAM is provided by a dual battery backup 8K SRAM DS1225. Input and output to the front panel is handled through U636 an MC68B21 PIA. Input and output to the generator is done through U628 an MCS6522 PIA. Input and output over the IEEE-488 bus is via U626, MC68B488P bus interface chip. Connection from the MPU to the generator can be made directly with a common ground system through connector J600. An optional opto-isolated buffer card which isolates the ground systems, connects through J601. At turn on the program executes a diagnostic check of ROM, RAM along with a front panel display light up test. It also checks non-volatile RAM for possible data corruption and initializes a cold start if a specific pattern is not correct.

SECTION 6

MAINTENANCE

WARNING!

This maintenance procedure should be performed by qualified personnel only. It is strongly recommended that extra precautions be taken when working with exposed circuitry, and that insulated probes and tools be used.

Shut the power switch off and disconnect the line cord from the power source before repairing or replacing components.

6.1 INTRODUCTION

This procedure is designed to localize a failure within the instrument to a PC Board level. Care should be taken to insure proper maintenance. After replacing the defective component(s), it may often be necessary to recalibrate either the whole instrument or at least the section which was affected.

When replacing components, a low wattage (10 to 25 watt) soldering iron should be used, and extreme care should be taken to avoid overheating the printed circuit foil. A suitable de-soldering tool is highly recommended to clear the holes before removing any integrated circuits.

6.2 MAINTENANCE PROCEDURE

For a list of the equipment required for this procedure, see Section 4, (page 4-1).

In the event the 2100 should fail to operate properly, the following procedure of each PC boards influence over operation will help guide you to localize that portion of the circuit at fault. To further assist in trouble shooting, -99 Recall will place the 2100 into the schematic test conditions corresponding to measurements shown on the schematic. If necessary variations in the operating conditions should be entered to engage the improper operation. If available, board substitution is an excellent method to verify problem isolation to board level. It is highly recommended that reference to section 5 Circuit Description be used to help in understanding circuit operation.

With any and all problems, correct power supply operation should be checked and verified before proceeding further. The following procedure assumes the power supplies are all operating to within the following limits.

+25.0V	±.05V
-25.0V	±.05V
+5.5V	±.1V
-5.5V	±.1V
+15.0V	±.75V
-15.0V	±.75V
+5.0V	±.25V (Use digital ground)

It is also advisable to do a visual inspection, looking for loose connectors or un-seated ICs in there sockets, burnt or discolored parts and foreign pieces of wire or metallic objects of any sort which could account for the problems.

The procedure describe portions of instrument operation influenced by each individual board. At points where signals are interconnected between boards there may be some overlap in this behavior. To use this listing, you must determine as completely as possible the nature of the malfunction, then reading down through each boards operating influence, determine if that board could be involved. The next step would be to verify your conclusions with internal measurements or board substitution. Once the problem board is identified, trouble shooting to component level can proceed.

6.2.1 POWER SUPPLY PC2100-7

Being the first item on your check list, it is appropriate we start here should a problem be discovered.

Three of the supplies are independent IC regulators. They are +15, -15 and +5. If one is bad it should not influence any other. The remaining supplies are discrete regulators involving op-amps and series pass transistors. They are inter-dependent for there reference as follows. The +25 is the master with all the others slaved to it. If it goes out the others will also be wrong and should be worked on first. The -5.5 gets it's reference from the -25 which gets it's from the +25. If the -25 is bad the -5.5 will also be wrong, requiring the -25 to be corrected before the -5.5.

Before trouble shooting a regulator, first verify with an oscilloscope that the unregulated (including ripple) is above (or below for a negative supply), the normal output voltage of that supply and the unregulated ripple is 120 Hz (100 Hz for 50 Hz line).

Example:

+15V supply unregulated and ripple should remain above +17V minimum allowing 2V for the regulator. This applies to all of the supplies. If the unregulated is lower than it should be, the problem most likely is in the unregulated and involves the electrolytic filter capacitor, rectifiers or transformer winding associated with the problem supply.

6.2.2 FRONT PANEL BOARD PC2100-4

When a particular key will not enter a value or execute and/or a particular LED or display element does not light, try the turn on check to verify.

When the knob fails to operate properly, or the unit seems to be running but the front panel does not light and control the unit, check the ribbon cable to the front panel, it may have come loose from it's socket.

6.2.3 MICROPROCESSOR (MPU) BOARD PC2100-3

Being the master controller, a subtle problem on this board such as a single PIA output line not working could produce wide spread behavior problems leading you in many directions. Generally a problem on this board will be caught in the self check or result in complete loss of control, including the display, with a wild and random effect on the unit.

If the self check does find a problem with RAM or ROM, the following will appear in the display as long as the problem is not severe enough to disable the self check operation.

bAd 1	U638	DS1225	non-volatile RAM
bAd 2	U635	2764D	ROM Not used with 2.8 and above.
bAd 3	U634	2764D	ROM
bAd 4	U631	2764D	ROM
bAd 5	U629	2764D	ROM

If at turn-on, the MPU automatically executes a cold start (see Section 2 for description of cold start) It indicates data corruption in the non-volatile RAM. If operation with power on is unaffected, it could be one of two things. The internal dual battery backup of the DS1225 has failed (data sheet life expectation is 10 years) or the power on reset circuit is not operating correctly. The power on reset circuit is split between this board and the power supply board PC2100-7 and consists of Q636, Q637 and associated components and Q1358 on PC2100-7 and associated components.

If an IC is suspected, a simple method of verification would be substitution or testing of the suspected parts. All ICs on this board are socketed to facilitate this process.

Prior to any removal of components verify that the supply to this board is correct and a clock signal is present on pin 37 U627. Crystal VF800 is responsible for providing the MPU clock.

6.2.4 PHASE LOCK LOOP BOARD PC2100-2

When a PLL error message, indicating one or more phase lock loops is not locked, check to see that the rear panel reference select switch is set for internal. Without a reference, the loops can't lock. Internally check for the 10MHz reference signal on TP1 and the 2.5MHz signal on TP2. Lock indicator LEDs for each loop are mounted on this board to further facilitate trouble

shooting. Interdependence between loops frequently will result in more than one loop not locking due to a failure in one of them. The best order to check the loops in is Low 4 Digit PLL, Top 3 Digit PLL, Sum PLL and the Output PLL last. Also see Main Generator Board section for PLL1, Output PLL error message. The schematic indicates both the range over which each loops VCO should operate and the frequency it should be operating at for the schematic test conditions, -99 Recall. A counter connected by 50 ohm cable, decoupled with a 100 ohm resistor at the test point end, can be use to measure these frequencies. Set the counter for AC coupling and adjust the trigger level for a stable reading. The VCO control voltage range and value for test conditions is also given.

When the locked modes of Continuous, Gate and Triggered Burst produce the correct frequency, but the unlock modes of Sweep and VC do not, the problem is in the unlocked mode control. In the unlocked modes the generator is controlled by U530, Unlocked Frequency DAC. Check this portion of circuit along with the switching circuitry that brings it in, Q547 and Q555.

6.2.5 MAIN GENERATOR BOARD PC2100-1

The Main Generator functions as the VCO for the Output PLL. It provides the above 30kHz sine and triangle along with a TTL signal for clocking the ROM Synthesizer. It also provides square waves for feed back to the Output PLL phase frequency detector and Square wave driver for above 30kHz squarewave output.

If the output PLL error message PLL1 is indicated, the output PLL is not locking. This condition involves both the PLL and the Main Generator board. To determine if the Main Generator is functioning properly as a VCO, set the Mode to VC and check that the unit puts out approximately the correct frequency over a range of settings. If it <u>does</u>, the problem is most likely in the Output PLL phase frequency detector and error amplifier filter circuits on the PLL board. If it does <u>not</u>, the problem is most likely on this board. Trouble shoot it starting with the control voltage on the VC Amplifiers, then the Current Sources, then into the Hysterisis Flip Flop and Triangle Buffer. If the VC Amplifiers and if the Current Sources seem to be functioning correctly, check for the 3V p-p triangle on TP28. If <u>TP28 is correct</u>, check for the 3V p-p square wave on TP30, follow it on to the ROM Board through a power splitter and then onto the PLL Board to the Output PLL phase detector. The output PLL requires this signal to function correctly. If the triangle on <u>TP28 is not present</u>, measure the DC voltage on TP28 and on pin 13 of U165. If the voltage on TP28 is of opposite polarity or if the same polarity but much smaller in value than pin 13, the problem is in the Triangle Buffer and associated components. If the problem is not in the Buffer as determined above, it must be in the Hysterisis Flip Flop or integrating capacitor switching, C135 and C160.

If the frequency selected is above 30kHz, and the sinewave is distorted or not present, the problem is in the Sine Shaper. The Sine Shaper circuit develops the sine waveform from the triangle, which feeds the Sine Buffer and is selected by K240 to feed the Main Output Waveform Select switching when the frequency is set above 30kHz and sine waveform selected. A failure in any element of that path can result in above 30kHz sinewave loss or distortion.

If the pulse output is not functioning correctly, the problem is the Pulse

Generator. The pulse generator is split between this card and the ROM Synthesizer Board. This card has the Pulse Width DAC, Current Source and timing capacitors on it. The ROM Board has the Pulse Generator Monostable Flip Flop, trigger source selector and positive or negative pulse output select. Refer to 6.2.6, ROM Synthesizer Board for more on this problem.

6.2.6 ROM SYNTHESIZER BOARD PC2100-5

If there are no Main Output waveforms below 30kHz, the problem is on the ROM Synthesizer Board. Be sure that continuous operation is selected. Start by checking for a waveform at TP37. If none is present check TP43 for +5.4V DC. This line must be high for the point address counters to count the waveform point clock. This line comes from the Gate/Trig control circuit and if found low, it indicates a problem from there. In continuous mode the Gate/Trig circuit is placed into the Gate mode and forced by the MPU to gate on continuously by turning on Q882. If TP43 is low, jump to the next paragraph and follow it, otherwise check for the waveform clock signal with an oscilloscope on TP42. If it is missing, follow it back through the divider chain to the Main Generator, if necessary. If it is there, look for pulse waveforms on the data in and out lines for the ROMs and latches indicating data flow from the point address counters through the ROMs and latches to the DAC, looking for a break in the flow. If none is found, the problem is in the DAC circuit. If TP37 is ok, follow the signal on through, all the way to the Main Output selector, if necessary, looking for the point of lost signal.

When the unti continues operation and does not work below 30kHz and TP43 is low, transistor Q882 should be switched on, pins 13 and 9 of U879 should be low, pin 9 and 15 of U876 should be low, pin 11 of U882 should be low and pin 10 high. Follow that path, looking for the point of disagreement, checking the associated components.

When distortion is present on the waveform below 30kHz, check to see if the distortion is a pattern that repeats within each cycle and all the ROM generated waveforms are distorted. If they are, the problem is in the data addressing of the Waveform ROMs or bit errors in the Waveform DAC. This group of devices is socketed to facilitate removal for testing or substitution. If only one waveform is distorted, the problem is in the Waveform ROMs and represents data corruption. If the distortion is of a clipping nature associated with analog components, look at TP37 with an oscilloscope and follow the signal through to the Main Output Waveform Selector on the Main Output Board, looking for the point of distortion.

If the Gate mode does not gate off, check the Internal Trigger Input levels. The External Trigger Input levels are normally set by R879 to be above zero volts, so that with no input connected (representing zero input), the unit will gate off. To check this adjustment, connect an external 10V p-p 500Hz signal, centered about ground, to the Trigger Input and observe with an oscilloscope that the 2100 gates off when the external signal goes below ground. If it does, refer to Section 7.3.20 to correct the adjustment. If the adjustment cannot be made correctly, check U880 and associated components. If the trigger level is not the problem, disconnect the external trigger input and proceed as follows.

Pins 13 and 9 of U879 must be high for the burst and hold counters to operate.

If they are not, check U879, U880 and associated components. If they are high, with an oscilloscope check for pulse waveforms on pin 15, and check the RCO output of the following ICs in the following order, U874, U877, U875 and U876. Check the first IC without a pulse output, and associated components.

When the Trigger Burst fails to burst, producing no output, set the 2100 frequency to 2kHz and connect an external 10V p-p 500Hz signal centered about ground, to the Trigger Input. Observe with an oscilloscope the signal on pin 4 of U880. It should be a square wave synchronous with the external input. If not , check U880 and the signal path to the External Trigger Input BNC. If it is alright, look at pin 9 of U879. It should sit high and pulse low for each cycle of the external input. Check U878, U879 and associated components. If ok, check pin 15, the RCO line out of U876, it should be low forcing TP43 high to start waveform generation. Check U876, U882 and associated components if incorrect.

When there is no pulse waveform on the Main Output, and the squarewave output is functioning normally, the problem is most likely in the pulse generator, if not, see the next paragraph on the Pulse Square Wave Driver. Start by checking the Pulse Enable line, pin 3 of U990, it should be high enabling the generator. If incorrect, check U990, latch U871 and associated components. If correct, check the Pulse Width DAC output on TP34 and the Pulse Width Current Source on pin 6 of U327 (both are on PC2100-1). The schematic voltage readings apply to -99 Recall with pulse waveform selected. If incorrect, check U300, U304, U327 and associated components. If ok look at pin 11 of U1009 for a trigger squarewave signal. If the trigger signal is present, check that pins 9 and 13 of U1009 are the same (high or low together). If they are not, check U1009. If If they are, measure the voltage on the collector of Q1030. If the voltage is below 1V and pin 9 of U1009 is high, or if the collector of Q1030 is above 2.9 volts and pin 9 is low, check Q1028. If the voltage is below 1V, and pin 13 of U1009 is low, or if the collector of Q1030 is above 2.9 volts and pin 13 is high, the problem is in the group of components between those two points on the schematic.

If the Square wave, pulse and TTL outputs are not functioning correctly, The problem can only involve the Pulse Square Wave Driver and drive select circuit.

The driver section consists of a current mode switch Q975 and Q977 with the TTL output on Q968's collector and the Main Output Waveform for the Output Selector on Q975's collector. The drive for this circuit comes through Q965, a common base transistor amplifier. The emitter of Q965 can be driven from one of three sources. The emitter of Q956 for pulse waveforms, the emitter of Q950 for below 30kHz square waveforms generated by U879 and the collector of Q959 for above 30kHz square waveforms from the Main Generator. Each drive can be disabled as follows. The pulse drive is disabled by locking the pulse generator output high with a low state on it's Pulse Enable line. This holds Q956 off. Similarly, the below 30kHz square wave is disabled by a low state on it's select line, locking it's output high which will hold Q950 off. The above 30kHz square wave is disabled by holding the base of Q958 high, turning Q959 off and preventing it from driving Q965's emitter. Only one source of drive will be active at any time.

6.2.7 MAIN OUTPUT BOARD PC2100-6

If the unit is producing large amplitude errors, the problem involves the 11 bit Amplitude Control or 20dB and 40dB Output Attenuators. If the error only shows up for amplitudes 1V peak and below, check the dB Output Attenuators, otherwise check the operation of each bit of the 11 bit Amplitude Control. Connect a true RMS AC voltmeter with 10 millivolts resolution at 10 volts, to the Main Output. Set the 2100 for a 500Hz, 1.28V peak square waveform output. Step the output amplitude up 10 millivolts peak at a time and observe on the meter a 10 millivolt change for each step. The step at which the change is more or less than 10mV indicates a bad bit. It can be a bit coming on or going off, both must be checked. Check the resistors, switching FETs, switch drivers and data latch associated with the suspected bit.

If the Main Output has a distorted or clipped output check to see if the signals arriving on this board through J1061, J1062 or J1063 are clean, Follow the signal through to the output looking for the point of distortion.

If there is no output waveform, with or without a large dc level, generally indicates a damaged or blown Output Amplifier. Set the 2100 for -99 Recall and look for a 10V p-p sinewave on TP53 or TP54. If the signal is there, look for an open, normally closed contact in K1270 or K1277, or shorted Triac Q1291. If the signal is not present, check for the 3V p-p sinewave on J1061 and TP49, then 1V p-p on TP50. If the signal is lost along this path, the problem is in the related circuit at the point of loss. If the signal on TP50 is correct, and on TP53 or TP54 is not, then the problem is in the Output Amplifier. Check for a blown fuse, F1001 and F1002. They will blow when the output transistors short. If one of them is blown, disconnect power to the 2100 and with a low voltage ohm meter check all of the output transistors for collector emitter shorts, replacing any suspected devices. Temporarily replace the fuses with 100 ohm resistors and connect a jumper from TP53 to TP54. Reconnect power to the 2100 and check the drop in voltage across the 100 ohm fuse replacements. If they are much greater than 5V, disconnect the power and again look for shorted devices. If the drop remains at or below 5V, check the Main Output for zero DC level and 10V p-p sinewave. If ok, replace the 100 ohm resistors with fuses and remove the jumper between TP53 and TP54. If the output is not correct, trouble shoot the circuit with the jumper in place, but replace the fuses.

SECTION 7

CALIBRATION

7.1 INTRODUCTION

This calibration procedure should be performed by qualified personnel only. It is strongly recommended that extra precautions be taken when working with exposed circuitry, and that insulated probes and tools be used.

> **CAUTION!**
>
> SHUT THE POWER SWITCH OFF AND DISCONNECT THE LINE CORD FROM THE POWER SOURCE BEFORE REPAIRING OR REPLACING COMPONENTS.

The following procedure is provided for the calibration and adjustment of the Model 2100. Adherence to this procedure should restore the generator to its original performance specifications. If the generator can not be calibrated by the procedure given, see Section 6 - Maintenance, or contact the factory Service Department. The location of all test points and adjustable components may be found in the component layout drawings at the rear of this manual.

7.2 EQUIPMENT REQUIRED

The following instruments are required to calibrate the Model 2100 properly:

1. OSCILLOSCOPE: bandwidth from dc to 100MHz, vertical sensitivity 5mV/cm, ac/dc coupled, Tektronix Model 2235 or equivalent.

2. FREQUENCY COUNTER: capable of measuring frequency or period fron .001Hz to 50MHz, 8 digit display, accuracy of 0.01ppm. HP Model 5316A with oven time base or equivalent.

3. TRUE RMS VOLTMETER: accuracy of 0.05% at 1kHz. Fluke Model 8920A or equivalent.

4. DC VOLTMETER: zero to 100V input, 1mV resolution. Fluke Model 8000 or equivalent.

5. DISTORTION ANALYZER: bandwidth of at least 500kHz, capable of measuring total harmonic distortion down to 0.01% (-80dB) below 100kHz. Krohn-Hite Model 6900A or equivalent.

7.3 TEST PROCEDURE

7.3.1 POWER SUPPLY (On PC2100-7)

Connect DVM set for DC from -25 to +25. (Low side to -25, high side to +25)
Adjust R1315 for 50.00V ±.01V.
Measure and reset if necessary.
Check supplies as follows:

	Tolerance
+25.0V	±.05V
-25.0V	±.05V
+5.5V	±.1V
-5.5V	±.1V
+15.0V	±.75V
-15.0V	±.75V
+5.0V	±.25V (Use digital ground)

7.3.2 PLL CONTROL VOLTAGE ADJUSTMENT

The following adjustments will require removing two of the shield covers on PC2100-2 (refer to PC2100-2 layout).

SETTING	TP	ADJUSTMENT	CONTROL VOLTAGE SETTING
30.01MHz	6	R442	3.00V ± .02V top 3 dig PLL
30.01MHz	11	R484	2.70V ± .02V sum PLL
3.001MHz	6	C444	0.30V ± .01V top 3 dig PLL
3.001MHz	11	C485	0.20V ± .01V sum PLL

Install shield covers.

Note: Use the above sequence of adjustments for minimum interaction. All PLL's should be locked now. Lock indicators on PC2100-2 should be lit.

7.3.3 PHASE DETECTOR BALANCE NULL (On PC2100-2)

Remove all connections to the 2100 not called for in the following set up to prevent ground loops from introducing hum.
Set 2100 for 33kHz.
Set scope gain to 5mV/cm or better sensitivity, AC coupled.
Connect X1 scope probe to TP15. Use PLL board ground.
Adjust R595 to null signal.

7.3.4 SQUAREWAVE LEVEL ADJUST (On PC2100-1 Main Generator)

With frequency set for 33kHz.

Connect scope with X10 probe to TP30.
Adjust R114 for 3Vp-p squarewave.
Adjust R100 to center waveform about zero.

7.3.5 TP28 DC LEVEL ADJUST (On PC2100-1)

Unit should have been running 15 min or more.
With frequency set for 33kHz.
Connect DVM to TP28. Use Main Generator for DVM ground.
Adjust R126 for zero ±1mV.

7.3.6 FREQUENCY CONTROL VOLTAGE ADJUST (On PC2100-1)

Set Xn for 10
Set frequency for 30.01kHz.
Connect DVM to TP21. Use Main Generator Ground.

The Main Generator board works over three frequency ranges. The purpose of this test is to check and set the bottom and top of each range and make them a factor of 10 in voltage apart bottom to top.

To force it into a particular range, use the Xn and ÷n to run the frequency above or below the desired point and then back to the desired frequency. This will move you through the range hysteresis.

FREQUENCY RANGE		
Low end	High end	
300.1kHz	3.001MHz	Check low end TP21 voltage. Adjust C148 for 10 times larger ± .05V on high end. Recheck low end and reset high end if necessary.
3.001MHz	30.01MHz	Check low end TP21 voltage. Adjust C123 for 10 times larger ± .05V on high end. Recheck low end and reset if necessary. If low end changed a lot re-due the 300.1kHz to 3.001MHz range and this range again.

7.3.7 DISTORTION ADJUST (On PC2100-1)

Set frequency for 33kHz.
Recheck TP28 DC level and reset to zero with R126, if necessary.
Set amplitude for 5V peak no load.
Set waveform to sinewave.
Connect 6900A Distortion Analyzer to main output.
Adjust R186, R196, and R199 on PC2100-1 for minimum distortion of ≤.22%.

7.3.8 SINEWAVE DC LEVEL AND AMPLITUDE ADJUST (On PC2100-1)

Set frequency for 33kHz.
Set waveform for sine.
Connect DVM to TP27.
Adjust R240 for zero DC level ±1mV.

Set 2100 amplitude for 5V Peak.
Connect scope to Main output without a terminator.
Set scope for **AC** coupling .5V/cm.
Using the position control on the scope offset waveform to see plus peak.
Using the triangle waveform for reference, set the sine waveform for the same peak amplitude with R208.
Recheck and reset sine DC level to zero on TP27 with R239.

7.3.9 ROM SYNTHESIZER AMPLITUDE MATCH UP TO MAIN GENERATOR BOARD (On PC2100-5)

Main Generator sine triangle match up must be correct at 33kHz.
Connect True RMS Voltmeter to main output without a terminator.
Set 2100 for continuous sinewave operation.
Set frequency for 33kHz.
Set Amplitude for 12V peak.
When reading settles set True RMS Voltmeter for dB and Relative operation.
Set 2100 frequency to 2kHz and adjust R861 for 0.00dB reading ±.01dB.
Set waveform to squarewave.
Adjust R980 for +3.00dB reading ±.01dB.
Leave True RMS Voltmeter connected to Main Output to monitor and correct any changes in amplitude when DC null is made.
Connect DVM to TP33.
Adjust R972 for squarewave DC level of zero ±1mV.
Reset +3.00dB ±.01dB with R980 if necessary. These two adjustments affect each other.
Connect DVM to TP37.
Set waveform to sine.
Adjust R860 for DAC buffer DC level of zero ±1mV.
Reset R861 for 0.00dB ±.01dB if necessary.

7.3.10 DC LEVEL ADJUST (On PC2100-6)

Allow 2100 15 min. warm-up time if turned on cold.
With generator set for 33kHz, triangle waveform 1.01 volts peak.
Connect DVM to TP49. Use output board analog ground for DVM low side.
Adjust R1101 for 0V ±10mV.
Connect DVM to TP52 and adjust R1219 for 20V ±.1V.
With amplitude set for 1.01V connect DVM to Main Output and adjust R1210 for 0V ±10mV on rear panel.
Set amplitude for 15V peak and re-adjust R1101 for 0V ±10mV on Main Output.
Repeat Main Output 1.01V and 15.0V DC level adjustments due to interaction.

7.3.11 33kHz SINEWAVE DC LEVEL ADJUST

With DVM connected to Main Output.
Set amplitude to 15.0V peak.
Set waveform to sinewave.
Adjust R240 on PC 2100-1 Main generator for zero ±10mV.

7.3.12 33kHz SINE AMPLITUDE ADJUST (On PC2100-6)

With frequency set for 33kHz.
Set amplitude to 15.0 volts peak.
Connect True RMS Voltmeter to Main Output.
Adjust R1264 for a reading of exactly 10.61V.

7.3.13 FIXED OFFSET ADJUST (On PC2100-6)

Set waveform to triangle.
Set fixed offset to (+).
Adjust R1097 for 7.50Vdc ±10mV.
Set fixed offset off.
Due to interaction, recheck step 7.3.12.

7.3.14 LOW FREQUENCY AMPLITUDE ADJUST

Set frequency to 2kHz, waveform to sine wave.
Connect True RMS Voltmeter to Main Output.
True RMS Voltmeter should read 10.61V exactly. If off <.03V, reset with R861 on ROM Synthesizer board.
If reading is off by more than .03V,a miss-match in High to Low frequency waveform exists in the generator and should be corrected by checking step 7.3.8 on Main Generator and Step 7.3.9 on ROM board.

7.3.15 LOW FREQUENCY SINE, TRIANGLE DC LEVEL ADJUST (PC2100-6)

With waveform to sinewave and amplitude set for 15V peak.
Adjust R1060 for 0Vdc ±10mV on Main Output.

7.3.16 SQUAREWAVE AMPLITUDE ADJUST (PC2100-5)

With 2100 set for 2kHz, 15.0V peak.
Set waveform to squarewave.
Adjust R980 on ROM board for a reading of exactly 15.00V ±0.01V.

7.3.17 SQUAREWAVE DC LEVEL ADJUST (PC2100-5)

Connect DVM to Main Output.
With generator set for 2kHz, 15V peak square waveform.
Adjust R972 on ROM board, for 0Vdc ±10mV.
Recheck squarewave amplitude and dc level until both are correct.

7.3.18 DC OFFSET ADJUST (On PC2100-6)

Set waveform to sine wave.
Set frequency to 2kHz.
Set amplitude to 1.01V peak.
Connect DVM set for DC to main output.
Set DC offset to zero.

Output should be 0 ±10mV. Reset R1210 on rear if necessary.
Set DC offset to -12.7V.
Adjust R1267 for correct reading of -12.7V ±.05V.

7.3.19 SQUAREWAVE CORNER ADJUST (On PC2100-6)

Connect main output to scope with 50 ohm terminator and 50 ohm cable.
Set DC offset to zero "0".
Set frequency to 2.5MHz.
Set waveform to squarewave.
Set amplitude to 10V peak.
Observe waveform an scope and adjust R1223 for optimum corner flatness.

7.3.20 TRIG INPUT LEVEL ADJUST (On PC2100-5)

Connect scope channel 1 to Main Output.
Connect external 500Hz triangle source to Trig Input and channel 2 of scope.
Set 2100 mode to gate, start phase to "0" and frequency to 30kHz.
With dual trace display trig from channel 2.
Set ext. 500Hz triangle for 3.0V p-p.
Adjust R879 for gate "on" at .7 to .8V of 500Hz triangle. Gate "off" should be equal to or above .5V level of triangle.

7.3.21 PULSE GENERATOR CALIBRATION

Connect scope to Main Output with 50Ω terminator.
Set 2100 to 5V peak.
Set waveform to squarewave.
Set mode to continuous.

> This calibration procedure uses the square waveform at particular frequencies to establish a pulse width reference on the scope. At these set frequencies and pulse widths, the pulse duty cycle should be 50% (equal time high and low). By comparing the pulse duty cycle, to that of the squarewave we have a measure of pulse accuracy.

To establish this reference with maximum scope resolution for each pulse width and frequency, set the scope as follows:

Set scope trigger for +slope, dc coupled and normal.
Set the frequency, pulse width, and sweep time called for in the chart below.
Set waveform to squarewave (VERY IMPORTANT).
With the Horizontal position control, center the FIRST negative going

transition.
Switch to pulse waveform and make adjustment.
Check both positive and negative pulse. If there is a small difference between the two, use the adjustment to make them equal.
Adjustments must be made in the order given.
If only one adjustment needed setting, it is necessary to check all that follows it.

Frequency	Pulse Width	Sweep Time X10 Mag	Adjustment <1/5cm
416.666Hz	1.2 msec	.2msec	R303
3.33333kHz	150µsec	20µsec	R306
416.666mHz	1.2sec	.2sec	R321
3.33333Hz	150msec	20msec	R307
416.666kHz	1.2µsec	.2µsec	C1029
3.33333MHz*	.15µsec	.1µsec	R1030
41.6666kHz	12µsec	2µsec	C335
333.333kHz	1.5µsec	.2µsec	R335

* Center FIRST negative transition of square waveform. There will be more than one.

7.3.22 HIGH FREQUENCY SINE & TRIANGLE RESPONSE

With Main Output connected to scope through a 50 ohm terminated cable.
Set waveform to sinewave.
Set amplitude to 10Vp.
Set frequency to 3MHz.
Set 2100 to log sweep from 1MHz to 31.16MHz (unit must have been self-calibrated recently) at 100mSec sweep time.
Connect ramp output to horizontal drive of scope & set scope for x y operation.
Observe response on scope and adjust C243 on main generator PC2100-1 for optimum flatness.
With the 1MHz end set for 6cm pp. Response should remain within 5.2cm to 6.8cm p-p.

3.23 FREQUENCY ACCURACY ADJUST

WARNING!

The unit must be running a minimum of 30 minutes and the covers must be on in order to perform this test.

This test is for the "Standard Reference" only (Non-Ovenized).
Connect frequency counter to TTL Output.
Set frequency to 30MHz.
Adjust 2100 reference for correct frequency reading, ±3Hz (adjustment is on rear panel).
If necessary, allow counter to overflow one digit to get enough resolution.

SECTION 8

PARTS LIST

8.1 ORDERING INFORMATION

When ordering parts from Krohn-Hite, specify the instrument MODEL NUMBER (Model 2100A), the instrument SERIAL NUMBER, the SCHEMATIC REFERENCE DESIGNATOR (R100, C200, CR300, etc.), and the MANUFACTURER'S PART NUMBER (see below).

Address all inquiries to your local Krohn-Hite Sales Representative or directly to Krohn-Hite.

Any Engineering modifications will be found on a Modifications Sheet inside the rear cover of this manual.

The part numbers listed are either the actual parts used or direct replacements.

8.2 ORDERING UNLISTED PARTS

When ordering parts from Krohn-Hite that are not listed, include the instrument MODEL NUMBER, instrument SERIAL NUMBER, and a description and location of the part.

MFR	NAME	FSCM
AV	Aavid Engineering, Laconia, NH	30161
AB	Allen Bradley Co., Milwaukee, WI	01121
AD	Analog Devices Inc., Norwood, MA	24355
ALC	Alco Electronic Products Inc., Div. of Augat Inc., North Andover, MA	95146
AMP	Amphenol North America, Div. of Buker-Ramo, Oak Brook, IL	29587
AMZ	American Zettler, Irvine, CA.	-----
APD	American Power Devices, Andover, MA	50273
AS	Atlantic Semiconductor, Northridge, CA	17545
ATM	Amatom Electronics Hardware, Windsor Locks, CT	06540
AVX	Aerovox Inc., New Bedford, MA	00656
BKM	Beckman Helipot Div., Fullerton, CA	73138
BUS	Bussman, Div. of McGraw-Edison Co., St. Louis, MO	71400
CA	Circuit Assembly, Costa Mesa, CA.	-----
CC	Coto-Coil Co., Providence, RI	71707
CD	Cornell-Dubilier Electronics, Newark, N.J.	14655
CDI	Compensated Devices Inc., Melrose, MA	-----
CGW	Corning Glass Works, Wilmington, NC	27167
CK	C&K Components Inc., Newton, MA	09353
CLX	Clairex Corp., Mt. Vernon, NY	-----
CPC	Components Corp., Denville, NJ	26364
CW	CW Industries, Warminster, PA	79727
DE	Dale Electronics Inc., Columbus, NE	91637
DLV	Delevan Corp., East Aurora, NY	99800
DL	Dialight Corp., Brooklyn, NY	72619
ECI	Electronic Concepts Inc., Eatontown, NJ	50558
FCD	Fairchild, Semiconductor Group, Mountain View, CA	07263
FXC	Ferroxcube Corp., Div. of N.A. Phillips, Saugerties, NY	02114
GI	General Instrument Corp., Semiconductor Div., Hicksville, NY	11711
HG	Hi-G Co., Windsor Locks, CT	02289
HP	Hewlett-Packard component supplied by Schweber, Bedford, MA	-----
ITT	ITT Components-Capacitors, Santa Ana, CA	-----
KGN	Kahgan Electronics Corp., Hempstead, NY	57582
KH	Krohn-Hite Corp., Avon, MA	88865
KLN	Kelvin Industries, Fajardo, PR	-----
KNG	Kings Electronics, Tuckahoe, NY	91836
KRL	KRL Electronics Inc., Manchester, NH	18235
LFI	Littlefuse Inc., Des Plaines, IL	75915
LNX	Lionex, Burlington, MA	-----
MAL	Mallory Capacitor Co., Indianapolis, IN	90201
MON	Monsanto, Electronics Div., Palo Alto, CA	26483
MOT	Motorola Inc., Semiconductor Group, Phoenix, AZ	04713
MT	M-Tron Industries Mfg. Inc., Van Nuys, CA	31649
NS	National Semiconductor Corp., Semiconductor Div., Santa Clara, CA	27014 -----
PRP	Precision Resistive Products Inc., Mediapolis, IA	-----
QC	Quality Components Inc., St. Mary's, PA	-----
RCA	RCA Solid State Div., Somerville, NJ	02735
RCL	RCL Electronics, Div. of AMF, Electro-Components Group, Pompano Beach, FL	-----
RI	Resistors Inc., Chicago, IL	83827
SCH	ITT Schadow Inc., Eden Prarie, MN	-----
SLX	Siliconix Inc., Sunnyvale, CA	100010
STL	Stackpole Components Co., Raliegh, NC	-----
SP	Sprague Electric Co., N. Adams, MA	56289
STT	Stettner-Trush Inc., Gazenovia, NY	52763
SUP	Superior Electric Company, Bristol, CT.	-----
SWC	Switchcraft Inc., Chicago, IL	82389
TD	Teledyne Semiconductor, Mountain View, CA	15818
TI	Texas Instruments, Dallas, TX	01295
TMY	Thermalloy, Dallas, TX	13103
TOR	Torin Corp., Torrington, CT	60399
TRW	TRW Capacitors, Ogallala, NE	84411
YSA	Yuasa Battery, Santa Fe, CA	-----

SCHEM REF	DESCRIPTION	MFR	MFR PART NUMBER	KH NUMBER
B1000	FAN TA300	TOR	A30473-10	018003
C101	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C102	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C103	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C104	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C105	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C107	330pF 5% 500V	ITT	DM15C331J	423133
C113	.047uF 20% 50V	TE	SR205E473MAA	413347
C114	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C117	.047uF 20% 50V	TE	SR205E473MAA	413347
C121	12pF 10% 500V	QUA	9213-12110	411012
C122	.047uF 20% 50V	TE	SR205E473MAA	413347
C123	4.5-20pF TRIMMER	ST	75-TRIKO-02	482008
C124	30pF 5% 500V	KGN	DM15C300J	422030
C130	.047uF 20% 50V	TE	SR205E473MAA	413347
C132	12pF 10% 500V	QUA	9213-12110	411012
C134	.01uF 20% 500V	KGN	5GAS-S10	412310
C135	30pF 5% 500V	KGN	DM15C300J	422030
C136	.01uF 20% 500V	KGN	5GAS-S10	412310
C139	.047uF 20% 50V	TE	SR205E473MAA	413347
C142	1pF 10% 500V	QUA	9210-01910	411001
C143	3.3pF 10% 500V	QUA	9210-33910	411933
C145	22pF 10% 500V	KGN	DM15C220K	423022
C148	4.5-20pF TRIMMER	ST	75-TRIKO-02	482008
C149	1000pF 20% 500V	KGN	5GA-D10	412210
C150	30pF 5% 500V	KGN	DM15C300J	422030
C152	.01uF 20% 500V	KGN	5GAS-S10	412310
C153	.01uF 20% 500V	KGN	5GAS-S10	412310
C157	.047uF 20% 50V	TE	SR205E473MAA	413347
C158	.047uF 20% 50V	TE	SR205E473MAA	413347
C159	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C160	510pF 10% 500V	KGN	DM15C511K	423151
C164	68pF 5% 500V	KGN	DM15C680J	422068
C165	.47uF 20% 100V	TE	C330C474M1U5CA	413447
C166	5.1pF 10% 500V	QUA	9210-51910	411951
C167	.047uF 20% 50V	TE	SR205E473MAA	413347
C169	100pF 10% 500V	KGN	DM15C101K	422110
C172	12pF 10% 500V	QUA	9213-12110	411012
C173	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C174	.047uF 20% 50V	TE	SR205E473MAA	413347
C175	.047uF 20% 50V	TE	SR205E473MAA	413347
C176	.047uF 20% 50V	TE	SR205E473MAA	413347
C180	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C181	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C182	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C183	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C187	22pF 10% 500V	KGN	DM15C220K	423022
C190	7.5pF 10% 500V	QUA	9210-75910	411975
C198	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C201	.047uF 20% 50V	TE	SR205E473MAA	413347
C211	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C215	.047uF 20% 50V	TE	SR205E473MAA	413347
C237	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C238	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C242	10pF 10% 500V	QUA	9213-10110	411010
C243	3-9pF TRIMMER	ST	75-TRIKO-02-N075	482003
C245	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C250	.1uF 20% 100V	TE	SR211E104MAA	413410
C251	.1uF 20% 100V	LNX	SR211E104MAA	413410
C252	.1uF 20% 100V	LNX	SR211E104MAA	413410
C255	.47uF 20% 100V	TE	C330C474M1U5CA	413447
C270	100pF 10% 500V	KGN	DM15C101K	422110
C273	.1uF 20% 100V	LNX	SR211E104MAA	413410
C276	100pF 10% 500V	KGN	DM15C101K	422110
C277	.1uF 20% 100V	LNX	SR211E104MAA	413410
C302	.1uF 20% 100V	LNX	SR211E104MAA	413410
C303	22pF 10% 500V	KGN	DM15C220K	423022
C304	62pF 5% 500V	KGN	DM15C620J	422062
C305	.1uF 20% 100V	LNX	SR211E104MAA	413410
C306	.1uF 20% 100V	LNX	SR211E104MAA	413410
C327	.1uF 20% 100V	LNX	SR211E104MAA	413410
C335	7-35pF TRIMMER	ST	75-TRIKO-02-N1500	482009
C336	820pF 5% 300V	KGN	DM15C821J	422182
C337	10000pF 1% 100V	KGN	DM20C103K	423310
C338	.1uF +1%-3% 200V	LNX	SR211E104MAA	452410
C339	1uF +0.5%- 3.5%	ITT	TAPA1M35	452510
C340	10uF 1/2% 50V	TRW	X663F-2	441610
C344	.1uF 20% 100V	LNX	SR211E104MAA	413410
C400	.01uF 20% 500V	KGN	5GAS-S10	412310
C401	.1uF 20% 100V	LNX	SR211E104MAA	413410
C402	.01uF 20% 500V	KGN	5GAS-S10	412310
C403	.01uF 20% 500V	KGN	5GAS-S10	412310
C404	.1uF 20% 100V	LNX	SR211E104MAA	413410
C405	.01uF 20% 500V	KGN	5GAS-S10	412310
C406	22pF 10% 500V	KGN	DM15C220K	423022
C407	.1uF 20% 100V	LNX	SR211E104MAA	413410
C408	.1uF 20% 100V	LNX	SR211E104MAA	413410
C409	.1uF 20% 100V	LNX	SR211E104MAA	413410
C410	100pF 10% 500V	KGN	DM15C101K	422110
C411	.1uF 20% 100V	LNX	SR211E104MAA	413410
C412	.33uF 20% 50V	KGN	DM15C033J	413433
C413	.22uF 20% 50V	TE	3420-50E-224M	413422
C414	.1uF 20% 100V	LNX	SR211E104MAA	413410
C415	.047uF 20% 50V	TE	SR205E473MAA	413347
C417	.1uF 20% 100V	LNX	SR211E104MAA	413410
C419	75pF 10% 500V	KGN	DM15C750K	423075
C422	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C423	.1uF 20% 100V	LNX	SR211E104MAA	413410
C424	.01uF 20% 500V	KGN	5GAS-S10	412310
C430	.1uF 20% 100V	LNX	SR211E104MAA	413410
C431	.1uF 20% 100V	LNX	SR211E104MAA	413410
C432	100pF 10% 500V	KGN	DM15C101K	422110
C433	.047uF 20% 50V	TE	SR205E473MAA	413347
C436	.1uF 20% 100V	LNX	SR211E104MAA	413410
C437	.1uF 20% 100V	LNX	SR211E104MAA	413410
C438	.0047uF 5% 200V	TRW	X463UW	451247
C440	.1uF 20% 100V	LNX	SR211E104MAA	413410
C441	.1uF 20% 100V	LNX	SR211E104MAA	413410
C442	27pF 5% 500V	KGN	DM15C270J	422027
C443	100pF 10% 500V	KGN	DM15C101K	422110
C444	7-35pF TRIMMER	ST	75-TRIKO-02-N1500	482009
C446	.1uF 20% 100V	LNX	SR211E104MAA	413410
C447	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C448	.01uF 20% 500V	KGN	5GAS-S10	412310
C449	.01uF 20% 500V	KGN	5GAS-S10	412310
C460	200pF 1% 500V	KGN	DM15C201F	422120
C462	.1uF 20% 100V	LNX	SR211E104MAA	413410
C463	.1uF 20% 100V	LNX	SR211E104MAA	413410
C465	.1uF 20% 100V	LNX	SR211E104MAA	413410
C470	.1uF 20% 100V	LNX	SR211E104MAA	413410
C473	.1uF 20% 100V	LNX	SR211E104MAA	413410
C474	.1uF 20% 100V	LNX	SR211E104MAA	413410
C477	.1uF 20% 100V	LNX	SR211E104MAA	413410
C478	.22uF 20% 50V	TE	3420-50E-224M	413422
C479	.047uF 20% 50V	TE	SR205E473MAA	413347
C480	.22uF 20% 50V	TE	3420-50E-224M	413422
C481	.1uF 20% 100V	LNX	SR211E104MAA	413410
C482	.047uF 20% 50V	TE	SR205E473MAA	413347
C483	27pF 5% 500V	KGN	DM15C270J	422027
C484	100pF 10% 500V	KGN	DM15C101K	422110
C485	7-35pF TRIMMER	ST	75-TRIKO-02-N1500	482009
C487	.1uF 20% 100V	LNX	SR211E104MAA	413410
C488	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C489	.01uF 20% 500V	KGN	5GAS-S10	412310
C502	.1uF 20% 100V	LNX	SR211E104MAA	413410
C504	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C506	.047uF 20% 50V	TE	SR205E473MAA	413347
C509	.1uF 20% 100V	LNX	SR211E104MAA	413410
C510	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C515	.1uF 20% 100V	LNX	SR211E104MAA	413410
C516	.1uF 20% 100V	LNX	SR211E104MAA	413410
C519	.1uF 20% 100V	LNX	SR211E104MAA	413410
C521	.1uF 20% 100V	LNX	SR211E104MAA	413410
C530	.1uF 20% 100V	LNX	SR211E104MAA	413410
C531	.1uF 20% 100V	LNX	SR211E104MAA	413410
C534	22pF 10% 500V	KGN	DM15C220K	423022
C550	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C560	10pF 10% 500V	QUA	9213-10110	411010
C561	.1uF 20% 100V	LNX	SR211E104MAA	413410
C562	.1uF 20% 100V	LNX	SR211E104MAA	413410
C563	.1uF 20% 100V	LNX	SR211E104MAA	413410
C564	.1uF 20% 100V	LNX	SR211E104MAA	413410
C565	.1uF 20% 100V	LNX	SR211E104MAA	413410
C566	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C567	4700pF 10% 100V	KGN	WMF1D47	431247
C578	51pF 10% 500V	KGN	DM15C510K	422051
C585	.1uF 20% 100V	LNX	SR211E104MAA	413410
C586	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C587	.1uF 20% 100V	LNX	SR211E104MAA	413410
C588	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C594	51pF 10% 500V	KGN	DM15C510K	422051
C596	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C600	.1uF 20% 100V	LNX	SR211E104MAA	413410
C604	.1uF 20% 100V	LNX	SR211E104MAA	413410
C608	.1uF 20% 100V	LNX	SR211E104MAA	413410
C610	.1uF 20% 100V	LNX	SR211E104MAA	413410
C611	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C620	.1uF 20% 100V	LNX	SR211E104MAA	413410
C621	.1uF 20% 100V	LNX	SR211E104MAA	413410
C622	.1uF 20% 100V	LNX	SR211E104MAA	413410
C623	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C624	.1uF 20% 100V	LNX	SR211E104MAA	413410
C625	18pF 5% 500V	KGN	DM15C180J	422018
C626	.1uF 20% 100V	LNX	SR211E104MAA	413410
C627	18pF 5% 500V	KGN	DM15C180J	422018
C628	.1uF 20% 100V	LNX	SR211E104MAA	413410
C629	.1uF 20% 100V	LNX	SR211E104MAA	413410
C630	.1uF 20% 100V	LNX	SR211E104MAA	413410
C631	.1uF 20% 100V	LNX	SR211E104MAA	413410
C634	.1uF 20% 100V	LNX	SR211E104MAA	413410
C635	.1uF 20% 100V	LNX	SR211E104MAA	413410
C636	.1uF 20% 100V	LNX	SR211E104MAA	413410
C637	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C638	.1uF 20% 100V	LNX	SR211E104MAA	413410
C800	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C850	.1uF 20% 100V	LNX	SR211E104MAA	413410
C851	.1uF 20% 100V	LNX	SR211E104MAA	413410
C852	.1uF 20% 100V	LNX	SR211E104MAA	413410
C853	.1uF 20% 100V	LNX	SR211E104MAA	413410
C854	.1uF 20% 100V	LNX	SR211E104MAA	413410
C855	.1uF 20% 100V	LNX	SR211E104MAA	413410
C856	.1uF 20% 100V	LNX	SR211E104MAA	413410
C857	.1uF 20% 100V	LNX	SR211E104MAA	413410
C858	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C859	.1uF 20% 100V	LNX	SR211E104MAA	413410
C860	.1uF 20% 100V	LNX	SR211E104MAA	413410
C861	.1uF 20% 100V	LNX	SR211E104MAA	413410
C871	.1uF 20% 100V	LNX	SR211E104MAA	413410
C872	.1uF 20% 100V	LNX	SR211E104MAA	413410
C873	.1uF 20% 100V	LNX	SR211E104MAA	413410
C874	.1uF 20% 100V	LNX	SR211E104MAA	413410
C875	.1uF 20% 100V	LNX	SR211E104MAA	413410
C876	.1uF 20% 100V	LNX	SR211E104MAA	413410
C877	.1uF 20% 100V	LNX	SR211E104MAA	413410

SCHEM REF	DESCRIPTION	MFR	MFR PART NUMBER	KH NUMBER
C878	.1uF 20% 100V	LNX	SR211E104MAA	413410
C879	.1uF 20% 100V	LNX	SR211E104MAA	413410
C880	10pF 10% 500V	QUA	9213-10110	411010
C881	.1uF 20% 100V	LNX	SR211E104MAA	413410
C882	.1uF 20% 100V	LNX	SR211E104MAA	413410
C883	.1uF 20% 100V	LNX	SR211E104MAA	413410
C884	.1uF 20% 100V	LNX	SR211E104MAA	413410
C885	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C886	.1uF 20% 100V	LNX	SR211E104MAA	413410
C887	.1uF 20% 100V	LNX	SR211E104MAA	413410
C888	2pF 10% 500V	QUA	9208-20910	411002
C889	2pF 10% 500V	QUA	9208-20910	411002
C901	.1uF 20% 100V	LNX	SR211E104MAA	413410
C902	.1uF 20% 100V	LNX	SR211E104MAA	413410
C909	.1uF 20% 100V	LNX	SR211E104MAA	413410
C910	.1uF 20% 100V	LNX	SR211E104MAA	413410
C912	1000pF 5% 500V	KGN	DM19C102J	421210
C917	940pF 1% 300V	KGN	DM15C941F	421194
C918	.01uF +1%-3% 200V	SP	5GASS10	452310
C919	.1uF +1%-3% 200V	SP	5GASS11	452410
C920	1uF +0.5%- 3.5%	SP	5GASS12	452510
C921	2000pF 1% 500V	KGN	DM19	421220
C922	.02uF 2% 200V	SP	5GASS20	452320
C923	.2uF 2% 200V	SP	5GASS21	452420
C924	2uF 2% 200V	SP	5GASS22	452520
C939	.1uF 20% 100V	LNX	SR211E104MAA	413410
C951	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C953	.1uF 20% 100V	LNX	SR211E104MAA	413410
C954	.1uF 20% 100V	LNX	SR211E104MAA	413410
C960	.1uF 20% 100V	LNX	SR211E104MAA	413410
C970	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C977	.047uF 20% 50V	TE	SR205E473MAA	413347
C978	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C982	.1uF 20% 100V	LNX	SR211E104MAA	413410
C990	.1uF 20% 100V	LNX	SR211E104MAA	413410
C1009	.1uF 20% 100V	LNX	SR211E104MAA	413410
C1027	.1uF 20% 100V	LNX	SR211E104MAA	413410
C1028	1000pF 20% 500V	KGN	5GA-D10	412210
C1029	7-35pF TRIMMER	ST	75-TRIKO-02-N1500	482009
C1030	75pF 10% 500V	KGN	DM15C750K	423075
C1086	.047uF 20% 50V	TE	SR205E473MAA	413347
C1087	.047uF 20% 50V	TE	SR205E473MAA	413347
C1088	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C1089	.047uF 20% 50V	TE	SR205E473MAA	413347
C1090	.47uF 20% 100V	TE	C330C474M1U5CA	413447
C1091	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C1092	62pF 5% 500V	KGN	DM15C620J	422062
C1100	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C1102	.1uF 20% 100V	LNX	SR211E104MAA	413410
C1104	.1uF 20% 100V	LNX	SR211E104MAA	413410
C1107	.1uF 20% 100V	LNX	SR211E104MAA	413410
C1186	.47uF 20% 100V	TE	C330C474M1U5CA	413447
C1210	.047uF 20% 50V	TE	SR205E473MAA	413347
C1212	.047uF 20% 50V	TE	SR205E473MAA	413347
C1213	.047uF 20% 50V	TE	SR205E473MAA	413347
C1215	.047uF 20% 50V	TE	SR205E473MAA	413347
C1216	.47uF 20% 100V	TE	C330C474M1U5CA	413447
C1217	.47uF 20% 100V	TE	C330C474M1U5CA	413447
C1222	10pF 10% 500V	KGN	DM15C100K	423022
C1223	2000pF 20% 1000V	KGN	5GA-D20	412220
C1224	.22uF 20% 50V	TE	3420-50E-224M	413422
C1225	.1uF 20% 100V	LNX	SR211E104MAA	413410
C1226	15pF 5% 500V	KGN	DM15C150J	423015
C1231	.47uF 20% 100V	TE	C330C474M1U5CA	413447
C1232	.47uF 20% 100V	TE	C330C474M1U5CA	413447
C1233	.47uF 20% 100V	TE	C330C474M1U5CA	413447
C1234	.1uF 20% 100V	LNX	SR211E104MAA	413410
C1235	51pF 10% 500V	KGN	DM15C510K	422051
C1236	.47uF 20% 100V	TE	C330C474M1U5CA	413447
C1241	5.1pF 10% 500V	QUA	9210-51910	411951
C1243	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C1244	.47uF 20% 100V	TE	C330C474M1U5CA	413447
C1245	.47uF 20% 100V	TE	C330C474M1U5CA	413447
C1246	.47uF 20% 100V	TE	C330C474M1U5CA	413447
C1247	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C1248	.47uF 20% 100V	TE	C330C474M1U5CA	413447
C1249	.47uF 20% 100V	TE	C330C474M1U5CA	413447
C1252	150pF 10% 500V	KGN	DM15C151K	422115
C1267	10pF 10% 500V	QUA	9213-10110	411010
C1268	10pF 10% 500V	QUA	9213-10110	411010
C1269	.1uF 20% 100V	LNX	SR211E104MAA	413410
C1270	.1uF 20% 100V	LNX	SR211E104MAA	413410
C1271	.1uF 20% 100V	LNX	SR211E104MAA	413410
C1276	.68pF 10% 500V	QUA	9205-68810	411906
C1281	5.6pF 10% 500V	QUA	9210-56910	411956
C1303	3300pF 20% 1000V	KGN	5GA-D33	412233
C1304	3300pF 20% 1000V	KGN	5GA-D33	412233
C1305	1000uF 50V	KGN	513D108M050EN4	471813
C1306	1000uF 50V	KGN	513D108M050EN4	471813
C1307	1uF 20% 35V	ITT	T350A105M035AF	471510
C1308	22pF 10% 500V	KGN	DM15C220K	423022
C1309	100pF 10% 500V	KGN	DM15C101K	422110
C1310	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C1311	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C1312	1uF 20% 35V	ITT	T350A105M035AF	471510
C1313	100pF 10% 500V	KGN	DM15C101K	422110
C1314	22pF 10% 500V	KGN	DM15C220K	423022
C1315	1uF 20% 35V	ITT	T350A105M035AF	471510
C1316	1uF 20% 35V	ITT	T350A105M035AF	471510
C1317	20uF 50V	ITT	TE1305	471620
C1318	20uF 50V	ITT	TE1305	471620
C1325	3300pF 20% 1000V	KGN	5GA-D33	412233
C1326	3300pF 20% 1000V	KGN	5GA-D33	412233
C1328	1000uF 50V	KGN	513D108M050EN4	471813

SCHEM REF	DESCRIPTION	MFR	MFR PART NUMBER	KH NUMBER
C1329	1000uF 50V	KGN	513D108M050EN4	471813
C1330	.1uF 20% 100V	LNX	SR211E104MAA	413410
C1331	.1uF 20% 100V	LNX	SR211E104MAA	413410
C1332	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C1333	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C1340	3300pF 20% 1000V	KGN	5GA-D33	412233
C1341	3300pF 20% 1000V	KGN	5GA-D33	412233
C1343	4700uF 16V	KGN	513D478M016FR4	471847
C1344	4700uF 16V	KGN	513D478M016FR4	471847
C1345	62pF 5% 500V	KGN	DM15C620J	422062
C1346	62pF 5% 500V	KGN	DM15C620J	422062
C1347	1uF 20% 35V	ITT	T350A105M035AF	471510
C1348	1uF 20% 35V	ITT	T350A105M035AF	471510
C1349	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C1350	6.8uF 20% 35V	ITT	T350F685M035AS	471568
C1355	3300pF 20% 1000V	KGN	5GA-D33	412233
C1356	3300pF 20% 1000V	KGN	5GA-D33	412233
C1357	1000uF 50V	KGN	513D108M050EN4	471813
C1358	4700uF 16V	KGN	513D478M016FR4	471847
C1359	.1uF 20% 100V	LNX	SR211E104MAA	413410
C1360	.1uF 20% 100V	LNX	SR211E104MAA	413410
C1361	6.8uF 20% 35V	ITT	T350F685M035AS	471568
CR021	DIODE SWITCHING	FCD	1N4149	234149
CR022	DIODE	HP	1N6263	286263
CR027	DIODE SWITCHING	FCD	1N4149	234149
CR030	DIODE	HP	1N6263	286263
CR134	DIODE	FCD	FD300	280300
CR149	DIODE SWITCHING	FCD	1N4149	234149
CR151	DIODE	FCD	FD300	280300
CR161	DIODE SWITCHING	FCD	1N4149	234149
CR184	DIODE SWITCHING	FCD	1N4149	234149
CR189	DIODE SWITCHING	FCD	1N4149	234149
CR278	DIODE SWITCHING	FCD	1N4149	234149
CR279	DIODE SWITCHING	FCD	1N4149	234149
CR335	DIODE	FCD	FD300	280300
CR340	DIODE	FCD	FD300	280300
CR404	DIODE SWITCHING	FCD	1N4149	234149
CR405	DIODE SWITCHING	FCD	1N4149	234149
CR438	DIODE	HP	1N6263	286263
CR462	DIODE SWITCHING	FCD	1N4149	234149
CR466	DIODE	HP	1N6263	286263
CR470	DIODE SWITCHING	FCD	1N4149	234149
CR473	DIODE SWITCHING	FCD	1N4149	234149
CR474	DIODE SWITCHING	FCD	1N4149	234149
CR475	DIODE SWITCHING	FCD	1N4149	234149
CR481	DIODE	HP	1N6263	286263
CR554	DIODE SWITCHING	FCD	1N4149	234149
CR555	DIODE SWITCHING	FCD	1N4149	234149
CR556	DIODE SWITCHING	FCD	1N4149	234149
CR559	DIODE SWITCHING	FCD	1N4149	234149
CR567	DIODE SWITCHING	FCD	1N4149	234149
CR568	DIODE	HP	1N6263	286263
CR569	DIODE	HP	1N6263	286263
CR576	DIODE	HP	1N6263	286263
CR577	DIODE	HP	1N6263	286263
CR588	DIODE SWITCHING	FCD	1N4149	234149
CR590	DIODE SWITCHING	FCD	1N4149	234149
CR637	DIODE SWITCHING	FCD	1N4149	234149
CR886	DIODE SWITCHING	FCD	1N4149	234149
CR887	DIODE SWITCHING	FCD	1N4149	234149
CR910	DIODE SWITCHING	FCD	1N4149	234149
CR915	DIODE SWITCHING	FCD	1N4149	234149
CR916	DIODE SWITCHING	FCD	1N4149	234149
CR962	DIODE	HP	1N6263	286263
CR1055	DIODE SWITCHING	FCD	1N4149	234149
CR1067	DIODE SWITCHING	FCD	1N4149	234149
CR1220	DIODE SWITCHING	FCD	1N4149	234149
CR1221	DIODE SWITCHING	FCD	1N4149	234149
CR1231	DIODE SWITCHING	FCD	1N4149	234149
CR1232	DIODE SWITCHING	FCD	1N4149	234149
CR1236	DIODE DUAL	FCD	MZ2361	202361
CR1286	DIODE SWITCHING	FCD	1N4149	234149
CR1287	DIODE SWITCHING	FCD	1N4149	234149
CR1288	DIODE SWITCHING	FCD	1N4149	234149
CR1289	DIODE SWITCHING	FCD	1N4149	234149
CR1303	DIODE RECTIFIER	FCD	1N4004	214004
CR1304	DIODE RECTIFIER	FCD	1N4004	214004
CR1305	DIODE RECTIFIER	FCD	1N4004	214004
CR1306	DIODE RECTIFIER	FCD	1N4004	214004
CR1315	DIODE SWITCHING	FCD	1N4149	234149
CR1317	DIODE RECTIFIER	DI	1N4002	244002
CR1318	DIODE RECTIFIER	DI	1N4002	244002
CR1325	DIODE RECTIFIER	FCD	1N4004	214004
CR1326	DIODE RECTIFIER	FCD	1N4004	214004
CR1327	DIODE RECTIFIER	FCD	1N4004	214004
CR1328	DIODE RECTIFIER	FCD	1N4004	214004
CR1329	DIODE RECTIFIER	FCD	1N4004	214004
CR1330	DIODE RECTIFIER	FCD	1N4004	214004
CR1332	DIODE SWITCHING	FCD	MR501	200500
CR1333	DIODE SWITCHING	FCD	MR501	200500
CR1340	DIODE SWITCHING	FCD	MR501	200500
CR1341	DIODE SWITCHING	FCD	MR501	200500
CR1342	DIODE SWITCHING	FCD	1N4149	234149
CR1343	DIODE SWITCHING	FCD	1N4149	234149
CR1344	DIODE SWITCHING	FCD	1N4149	234149
CR1345	DIODE SWITCHING	FCD	1N4149	234149
CR1346	DIODE SWITCHING	FCD	1N4149	234149
CR1347	DIODE SWITCHING	FCD	1N4149	234149
CR1348	DIODE SWITCHING	FCD	1N4149	234149
CR1349	DIODE RECTIFIER	FCD	1N4004	214004
CR1350	DIODE RECTIFIER	FCD	1N4004	214004

SCHEM REF	DESCRIPTION	MFR	MFR PART NUMBER	KH NUMBER
CR1355	DIODE SWITCHING	FCD	MR501	200500
CR1356	DIODE SWITCHING	FCD	MR501	200500
CR1357	DIODE SWITCHING	FCD	MR501	200500
CR1358	DIODE SWITCHING	FCD	MR501	200500
CR1359	DIODE SWITCHING	FCD	1N4149	234149
CR1360	DIODE RECTIFIER	FCD	1N4004	214004
DS409	LED GREEN	SDW	SLR34MG3	290343G
DS430	LED GREEN	SDW	SLR34MG3	290343G
DS466	LED GREEN	SDW	SLR34MG3	290343G
DS569	LED GREEN	SDW	SLR34MG3	290343G
DS810	LED GREEN	SDW	SLR34MG3	290343G
DS811	LED GREEN	SDW	SLR34MG3	290343G
DS812	LED GREEN	SDW	SLR34MG3	290343G
DS813	LED GREEN	SDW	SLR34MG3	290343G
DS814	LED GREEN	SDW	SLR34MG3	290343G
DS815	LED GREEN	SDW	SLR34MG3	290343G
DS816	LED GREEN	SDW	SLR34MG3	290343G
DS817	LED GREEN	SDW	SLR34MG3	290343G
DS818	LED GREEN	SDW	SLR34MG3	290343G
DS819	LED YELLOW	SDW	SLR34Y3	290343Y
DS837	LED GREEN	SDW	SLR34MG3	290343G
DS838	LED GREEN	SDW	SLR34MG3	290343G
DS839	LED GREEN	SDW	SLR34MG3	290343G
DS840	LED GREEN	SDW	SLR34MG3	290343G
DS841	LED GREEN	SDW	SLR34MG3	290343G
DS842	LED GREEN	SDW	SLR34MG3	290343G
DS843	LED GREEN	SDW	SLR34MG3	290343G
DS844	LED GREEN	SDW	SLR34MG3	290343G
DS845	LED GREEN	SDW	SLR34MG3	290343G
DS846	LED GREEN	SDW	SLR34MG3	290343G
DS847	LED GREEN	SDW	SLR34MG3	290343G
F1000	FUSE SLOW BLOW	BUS	MDX 1 1/4A	021013
F1001	FUSE FAST BLOW	BUS	SP1-300mA	021021
F1002	FUSE FAST BLOW	BUS	SP1-300mA	021021
G1100	TONE GENERATOR	MOT	MCP320B2	036079
J100	CONNECTOR	AMP	39-26-7345	015057
J101	CONNECTOR	AMP	22-03-2061	015037
J102	CONNECTOR BNC	AMP	31-010	370402
J103	CONNECTOR BNC	AMP	31-010	370402
J106	PHONO JACK	AMP	NTT-333	024010
J110	PHONO JACK	AMP	NTT-333	024010
J189	PHONO JACK	AMP	NTT-333	024010
J246	PHONO JACK	AMP	NTT-333	024010
J300	CONNECTOR	AMP	22-03-2061	015037
J400	CONNECTOR	AMP	39-26-7345	015057
J401	CONNECTOR	AMP	22-03-2061	015037
J404	CONNECTOR RIGHT ANGLE BNC	AMP	227161-1	370403
J405	CONNECTOR RIGHT ANGLE BNC	AMP	227161-1	370403
J555	PHONO JACK	AMP	NTT-333	024010
J556	CONNECTOR BNC	AMP	31-010	370402
J560	PHONO JACK	AMP	NTT-333	024010
J596	PHONO JACK	AMP	NTT-333	024010
J600	CONNECTOR	AMP	39-26-7345	015057
J601	CONNECTOR	AMP	39-26-7345	015057
J620	CONNECTOR REAR MATE	AMP	552791-2	015005
J636	CONNECTOR	AMP	39-26-7265	015039
J800	CONNECTOR	AMP	39-26-7265	015039
J801	CONNECTOR FEMALE	AMP	22-01-2041	015050
J850	PHONO JACK	AMP	NTT-333	024010
J870	CONNECTOR	AMP	39-26-7345	015057
J887	PHONO JACK	AMP	NTT-333	024010
J888	CONNECTOR BNC	AMP	31-010	370402
J912	PHONO JACK	AMP	NTT-333	024010
J963	PHONO JACK	AMP	NTT-333	024010
J964	PHONO JACK	AMP	NTT-333	024010
J966	PHONO JACK	AMP	NTT-333	024010
J967	CONNECTOR BNC	AMP	31-010	370402
J973	PHONO JACK	AMP	NTT-333	024010
J1061	PHONO JACK	AMP	NTT-333	024010
J1062	PHONO JACK	AMP	NTT-333	024010
J1063	PHONO JACK	AMP	NTT-333	024010
J1200	CONNECTOR	AMP	39-26-7345	015057
J1280	PHONO JACK	AMP	NTT-333	024010
J1283	CONNECTOR BNC	AMP	31-010	370402
J1300	CONNECTOR	AMP	39-26-7342	015041
J1301	CONNECTOR MALE	AMP	09-64-1091	015030
J1302	CONNECTOR MALE	AMP	09-64-1091	015030
K170	RELAY	CTO	1426-3-1 SPDT	029026
K240	RELAY EPOXY COATED	CTO	A4172-1	029024
K275	RELAY EPOXY COATED	CTO	A4172-1	029024
K280	RELAY EPOXY COATED	CTO	A4172-1	029024
K1270	RELAY CRYSTAL CAN	HG	DPDT HI-G 2K-4609/B	029001
K1277	RELAY CRYSTAL CAN	HG	DPDT HI-G 2K-4609/B	029001
K1290	RELAY CRYSTAL CAN	HG	DPDT HI-G 2K-4609/B	029001
L105	CHOKE 8.2uH	DLV	1537-34	001007
L112	FERRITE BEAD	KH	57-0181	019001
L171	CHOKE 5.6uH	DLV	1537-30	001006
L970	CHOKE 8.2uH	DLV	1537-34	001007
L979	FERRITE BEAD	KH	57-0181	019001
L989	CHOKE 8.2uH	DLV	1537-34	001007
L1088	CHOKE 8.2uH	DLV	1537-34	001007
L1216	CHOKE 8.2uH	DLV	1537-34	001007
P801	ENCODER DIGITAL	HWL	PC10C 24PPR	290006
Q107	TRANSISTOR, NPN	MOT	MPS2369	202369
Q110	TRANSISTOR, NPN	MOT	2N5836	205836
Q111	TRANSISTOR, NPN	MOT	MPS2369	202369
Q118	TRANSISTOR, PNP	MOT	2N3906	203906
Q120	TRANSISTOR, PNP	MOT	2N3906	203906
Q122	TRANSISTOR, PNP	MOT	2N5771	204258
Q123	TRANSISTOR, PNP	MOT	2N5771	204258
Q135	TRANSISTOR, PNP	MOT	2N5087	205087
Q136	TRANSISTOR, PNP	MOT	2N5087	205087
Q137	TRANSISTOR, PNP	MOT	MPS3640	203640
Q138	TRANSISTOR, PNP	MOT	MPS3640	203640
Q146	TRANSISTOR, NPN	MOT	MPS2369	202369
Q149	TRANSISTOR, PNP	MOT	MPS3640	203640
Q151	TRANSISTOR, NPN	MOT	MPS6515	206515
Q153	TRANSISTOR, NPN	MOT	MPS6515	206515
Q155	TRANSISTOR, FET	MOT	MPF4392	204392
Q157	TRANSISTOR, FET	MOT	U441	260421
Q158	TRANSISTOR, PNP	MOT	2N3906	203906
Q159	TRANSISTOR, FET	MOT	MPF4392	204392
Q160	TRANSISTOR, FET	MOT	MPF4392	204392
Q161	TRANSISTOR, FET	MOT	MPF4392	204392
Q166	TRANSISTOR, NPN	MOT	MM8009	208009
Q185	TRANSISTOR, PNP	MOT	2N5087	205087
Q186	TRANSISTOR, PNP	MOT	2N5087	205087
Q188	TRANSISTOR, NPN	MOT	MPS6515	206515
Q190	TRANSISTOR, NPN	MOT	MPS6515	206515
Q215	TRANSISTOR, NPN	MOT	MPS2369	202369
Q221	TRANSISTOR, NPN	MOT	MPS2369	202369
Q227	TRANSISTOR, NPN	MOT	MPS2369	202369
Q233	TRANSISTOR, NPN	MOT	MPS2369	202369
Q237	TRANSISTOR, PNP	MOT	MPS3640	203640
Q238	TRANSISTOR, PNP	MOT	MPS3640	203640
Q245	TRANSISTOR, PNP	MOT	MPS3640	203640
Q253	TRANSISTOR, PNP	MOT	2N5087	205087
Q254	TRANSISTOR, FET	MOT	MPF4391	204391
Q255	TRANSISTOR, PNP	MOT	2N5087	205087
Q256	TRANSISTOR, NPN	MOT	2N3904	203904
Q257	TRANSISTOR, NPN	MOT	2N3904	203904
Q258	TRANSISTOR, NPN	MOT	2N3904	203904
Q259	TRANSISTOR, NPN	MOT	2N3904	203904
Q274	TRANSISTOR, NPN	MOT	2N3904	203904
Q275	TRANSISTOR, FET	MOT	MPF4393	204393
Q280	TRANSISTOR, PNP	MOT	2N3906	203906
Q281	TRANSISTOR, NPN	MOT	2N3904	203904
Q301	TRANSISTOR, NPN	MOT	2N3904	203904
Q306	TRANSISTOR, FET	MOT	MPF4391	204391
Q320	TRANSISTOR, FET	MOT	MPF4391	204391
Q325	TRANSISTOR, FET	MOT	MPF4391	204391
Q336	TRANSISTOR, FET	MOT	MPF4391	204391
Q337	TRANSISTOR, FET	MOT	MPF4391	204391
Q338	TRANSISTOR, FET	MOT	MPF4391	204391
Q339	TRANSISTOR, FET	MOT	MPF4391	204391
Q340	TRANSISTOR, FET	MOT	MPF4391	204391
Q341	TRANSISTOR, FET	MOT	MPF4391	204391
Q342	TRANSISTOR, FET	MOT	MPF4391	204391
Q344	TRANSISTOR, PNP	MOT	2N5087	205087
Q346	TRANSISTOR, PNP	MOT	2N5087	205087
Q348	TRANSISTOR, PNP	MOT	2N5087	205087
Q350	TRANSISTOR, PNP	MOT	2N5087	205087
Q352	TRANSISTOR, PNP	MOT	2N5087	205087
Q354	TRANSISTOR, PNP	MOT	2N5087	205087
Q356	TRANSISTOR, PNP	MOT	2N5087	205087
Q358	TRANSISTOR, PNP	MOT	2N5087	205087
Q360	TRANSISTOR, FET	MOT	MPF4391	204391
Q464	TRANSISTOR, PNP	MOT	2N3906	203906
Q465	TRANSISTOR, PNP	MOT	2N3906	203906
Q468	TRANSISTOR, NPN	MOT	MPS6515	206515
Q506	TRANSISTOR, PNP	MOT	MPS3640	203640
Q530	TRANSISTOR, NPN	MOT	2N3904	203904
Q531	TRANSISTOR, NPN	MOT	2N3904	203904
Q545	TRANSISTOR, PNP	MOT	2N5087	205087
Q546	TRANSISTOR, PNP	MOT	2N5087	205087
Q547	TRANSISTOR, FET	MOT	MPF4392	204392
Q550	TRANSISTOR, FET	MOT	MPF4392	204392
Q551	TRANSISTOR, PNP	MOT	2N5087	205087
Q554	TRANSISTOR, FET	MOT	MPF4392	204392
Q555	TRANSISTOR, FET	MOT	MPF4392	204392
Q556	TRANSISTOR, FET	MOT	MPF4392	204392
Q557	TRANSISTOR, FET	MOT	MPF4392	204392
Q574	TRANSISTOR, FET	MOT	MPF4391	204391
Q576	TRANSISTOR, FET	MOT	MPF4391	204391
Q587	TRANSISTOR, PNP	MOT	2N5087	205087
Q588	TRANSISTOR, PNP	MOT	2N5087	205087
Q636	TRANSISTOR, NPN	MOT	MPS6515	206515
Q637	TRANSISTOR, NPN	MOT	MPS6515	206515
Q820	TRANSISTOR, PNP	MOT	MPS-A55	220093
Q821	TRANSISTOR, PNP	MOT	MPS-A55	220093
Q822	TRANSISTOR, PNP	MOT	MPS-A55	220093
Q823	TRANSISTOR, PNP	MOT	MPS-A55	220093
Q824	TRANSISTOR, PNP	MOT	MPS-A55	220093
Q825	TRANSISTOR, PNP	MOT	MPS-A55	220093

SCHEM REF	DESCRIPTION	MFR	MFR PART NUMBER	KH NUMBER
Q826	TRANSISTOR, PNP	MOT	MPS-A55	220093
Q827	TRANSISTOR, PNP	MOT	MPS-A55	220093
Q832	TRANSISTOR, NPN	MOT	MPS6515	206515
Q833	TRANSISTOR, NPN	MOT	MPS6515	206515
Q834	TRANSISTOR, NPN	MOT	MPS6515	206515
Q835	TRANSISTOR, NPN	MOT	MPS6515	206515
Q836	TRANSISTOR, NPN	MOT	MPS6515	206515
Q837	TRANSISTOR, NPN	MOT	MPS6515	206515
Q838	TRANSISTOR, NPN	MOT	MPS6515	206515
Q839	TRANSISTOR, NPN	MOT	MPS6515	206515
Q840	TRANSISTOR, NPN	MOT	MPS6515	206515
Q841	TRANSISTOR, NPN	MOT	MPS6515	206515
Q842	TRANSISTOR, NPN	MOT	MPS6515	206515
Q843	TRANSISTOR, NPN	MOT	MPS6515	206515
Q859	TRANSISTOR, NPN	MOT	MPS3646	203646
Q882	TRANSISTOR, PNP	MOT	2N3906	203906
Q884	TRANSISTOR, PNP	MOT	2N5087	205087
Q886	TRANSISTOR, FET	MOT	MPF4392	204392
Q900	TRANSISTOR, FET	MOT	MPF4391	204391
Q901	TRANSISTOR, FET	MOT	MPF4391	204391
Q905	TRANSISTOR, FET	MOT	MPF4391	204391
Q909	TRANSISTOR, FET	MOT	MPF4391	204391
Q915	TRANSISTOR, FET	MOT	MPF4391	204391
Q916	TRANSISTOR, FET	MOT	MPF4391	204391
Q917	TRANSISTOR, FET	MOT	MPF4391	204391
Q918	TRANSISTOR, FET	MOT	MPF4391	204391
Q919	TRANSISTOR, FET	MOT	MPF4391	204391
Q920	TRANSISTOR, FET	MOT	MPF4391	204391
Q921	TRANSISTOR, FET	MOT	MPF4391	204391
Q922	TRANSISTOR, FET	MOT	MPF4391	204391
Q923	TRANSISTOR, FET	MOT	MPF4391	204391
Q924	TRANSISTOR, FET	MOT	MPF4391	204391
Q925	TRANSISTOR, PNP	MOT	2N5087	205087
Q926	TRANSISTOR, FET	MOT	MPF4391	204391
Q927	TRANSISTOR, PNP	MOT	2N5087	205087
Q929	TRANSISTOR, PNP	MOT	2N5087	205087
Q930	TRANSISTOR, PNP	MOT	2N5087	205087
Q931	TRANSISTOR, PNP	MOT	2N5087	205087
Q932	TRANSISTOR, PNP	MOT	2N5087	205087
Q933	TRANSISTOR, PNP	MOT	2N5087	205087
Q934	TRANSISTOR, PNP	MOT	2N5087	205087
Q950	TRANSISTOR, PNP	MOT	2N5771	204258
Q956	TRANSISTOR, PNP	MOT	2N5771	204258
Q958	TRANSISTOR, NPN	MOT	MPS2369	202369
Q959	TRANSISTOR, NPN	MOT	MPS2369	202369
Q965	TRANSISTOR, PNP	MOT	2N5771	204258
Q968	TRANSISTOR, NPN	MOT	MPS2369	202369
Q975	TRANSISTOR, NPN	MOT	2N5836	205836
Q977	TRANSISTOR, NPN	MOT	MPS2369	202369
Q990	TRANSISTOR, NPN	MOT	2N3904	203904
Q993	TRANSISTOR, PNP	MOT	2N5087	205087
Q994	TRANSISTOR, PNP	MOT	2N5087	205087
Q996	TRANSISTOR, FET	MOT	MPF4391	204391
Q997	TRANSISTOR, FET	MOT	MPF4391	204391
Q1000	TRANSISTOR, PNP	MOT	2N5087	205087
Q1001	TRANSISTOR, PNP	MOT	2N5087	205087
Q1002	TRANSISTOR, PNP	MOT	2N5087	205087
Q1006	TRANSISTOR, FET	MOT	MPF4391	204391
Q1007	TRANSISTOR, FET	MOT	MPF4391	204391
Q1008	TRANSISTOR, FET	MOT	MPF4391	204391
Q1020	TRANSISTOR, PNP	MOT	MPS3640	203640
Q1021	TRANSISTOR, NPN	MOT	MPS3646	203646
Q1025	TRANSISTOR, PNP	MOT	MPS3640	203640
Q1026	TRANSISTOR, PNP	MOT	MPS3640	203640
Q1027	TRANSISTOR, NPN	MOT	U402	272366
Q1028	TRANSISTOR, PNP	MOT	2N5771	204258
Q1029	TRANSISTOR, PNP	MOT	2N5087	205087
Q1030	TRANSISTOR, PNP	MOT	2N5087	205087
Q1031	TRANSISTOR, FET	MOT	MPF4391	204391
Q1050	TRANSISTOR, FET	MOT	MPF4393	204393
Q1051	TRANSISTOR, FET	MOT	MPF4393	204393
Q1052	TRANSISTOR, NPN	MOT	2N3904	203904
Q1054	TRANSISTOR, PNP	MOT	2N3906	203906
Q1055	TRANSISTOR, PNP	MOT	2N3906	203906
Q1058	TRANSISTOR, NPN	MOT	2N3904	203904
Q1064	TRANSISTOR, FET	MOT	MPF4391	204391
Q1065	TRANSISTOR, FET	MOT	MPF4391	204391
Q1066	TRANSISTOR, FET	MOT	MPF4391	204391
Q1067	TRANSISTOR, PNP	MOT	MPS3640	203640
Q1068	TRANSISTOR, PNP	MOT	2N5087	205087
Q1069	TRANSISTOR, PNP	MOT	2N5087	205087
Q1070	TRANSISTOR, PNP	MOT	2N5087	205087
Q1071	TRANSISTOR, PNP	MOT	2N5087	205087
Q1076	TRANSISTOR, PNP	MOT	2N5087	205087
Q1077	TRANSISTOR, FET	MOT	MPF4391	204391
Q1078	TRANSISTOR, PNP	MOT	2N5087	205087
Q1079	TRANSISTOR, FET	MOT	MPF4391	204391
Q1082	TRANSISTOR, FET	MOT	MPF4391	204391
Q1088	TRANSISTOR, PNP	MOT	MPS3640	203640
Q1091	TRANSISTOR, PNP	MOT	2N5836	205836
Q1102	TRANSISTOR, PNP	MOT	2N3904	203904
Q1103	TRANSISTOR, NPN	MOT	2N3904	203904
Q1104	TRANSISTOR, NPN	MOT	2N3904	203904
Q1105	TRANSISTOR, NPN	MOT	2N3904	203904
Q1106	TRANSISTOR, NPN	MOT	2N3904	203904
Q1107	TRANSISTOR, NPN	MOT	2N3904	203904
Q1111	TRANSISTOR, PNP	MOT	2N5087	205087
Q1112	TRANSISTOR, FET	MOT	MPF4391	204391
Q1113	TRANSISTOR, PNP	MOT	2N5087	205087
Q1115	TRANSISTOR, PNP	MOT	2N5087	205087
Q1116	TRANSISTOR, FET	MOT	MPF4391	204391
Q1117	TRANSISTOR, PNP	MOT	2N5087	205087
Q1119	TRANSISTOR, PNP	MOT	2N5087	205087
Q1120	TRANSISTOR, FET	MOT	MPF4391	204391

SCHEM REF	DESCRIPTION	MFR	MFR PART NUMBER	KH NUMBER
Q1121	TRANSISTOR, PNP	MOT	2N5087	205087
Q1123	TRANSISTOR, PNP	MOT	2N5087	205087
Q1124	TRANSISTOR, FET	MOT	MPF4391	204391
Q1125	TRANSISTOR, PNP	MOT	2N5087	205087
Q1127	TRANSISTOR, PNP	MOT	2N5087	205087
Q1128	TRANSISTOR, FET	MOT	MPF4391	204391
Q1129	TRANSISTOR, PNP	MOT	2N5087	205087
Q1131	TRANSISTOR, PNP	MOT	2N5087	205087
Q1132	TRANSISTOR, FET	MOT	MPF4391	204391
Q1133	TRANSISTOR, PNP	MOT	2N5087	205087
Q1135	TRANSISTOR, PNP	MOT	2N5087	205087
Q1136	TRANSISTOR, FET	MOT	MPF4391	204391
Q1137	TRANSISTOR, PNP	MOT	2N5087	205087
Q1139	TRANSISTOR, PNP	MOT	2N5087	205087
Q1140	TRANSISTOR, FET	MOT	MPF4391	204391
Q1141	TRANSISTOR, PNP	MOT	2N5087	205087
Q1143	TRANSISTOR, PNP	MOT	2N5087	205087
Q1144	TRANSISTOR, FET	MOT	MPF4391	204391
Q1145	TRANSISTOR, PNP	MOT	2N5087	205087
Q1147	TRANSISTOR, PNP	MOT	2N5087	205087
Q1148	TRANSISTOR, FET	MOT	MPF4391	204391
Q1149	TRANSISTOR, PNP	MOT	2N5087	205087
Q1151	TRANSISTOR, PNP	MOT	2N5087	205087
Q1152	TRANSISTOR, FET	MOT	MPF4391	204391
Q1153	TRANSISTOR, PNP	MOT	2N5087	205087
Q1160	TRANSISTOR, FET	MOT	MPF4391	204391
Q1161	TRANSISTOR, FET	MOT	MPF4391	204391
Q1162	TRANSISTOR, FET	MOT	MPF4391	204391
Q1163	TRANSISTOR, FET	MOT	MPF4391	204391
Q1164	TRANSISTOR, FET	MOT	MPF4391	204391
Q1165	TRANSISTOR, FET	MOT	MPF4391	204391
Q1166	TRANSISTOR, FET	MOT	MPF4391	204391
Q1167	TRANSISTOR, FET	MOT	MPF4391	204391
Q1168	TRANSISTOR, FET	MOT	MPF4391	204391
Q1169	TRANSISTOR, FET	MOT	MPF4391	204391
Q1170	TRANSISTOR, FET	MOT	MPF4391	204391
Q1171	TRANSISTOR, FET	MOT	MPF4391	204391
Q1172	TRANSISTOR, FET	MOT	MPF4391	204391
Q1173	TRANSISTOR, FET	MOT	MPF4391	204391
Q1174	TRANSISTOR, FET	MOT	MPF4391	204391
Q1175	TRANSISTOR, FET	MOT	MPF4391	204391
Q1176	TRANSISTOR, FET	MOT	MPF4391	204391
Q1177	TRANSISTOR, FET	MOT	MPF4391	204391
Q1178	TRANSISTOR, FET	MOT	MPF4391	204391
Q1179	TRANSISTOR, FET	MOT	MPF4391	204391
Q1180	TRANSISTOR, FET	MOT	MPF4391	204391
Q1181	TRANSISTOR, FET	MOT	MPF4391	204391
Q1225	TRANSISTOR, PNP	MOT	2N5160	205160
Q1231	TRANSISTOR, NPN	MOT	MM8009	208009
Q1234	TRANSISTOR, PNP	MOT	2N5583	205583
Q1235	TRANSISTOR, NPN	MOT	2N4428	204428
Q1244	TRANSISTOR, NPN	MOT	2N2219A	202219
Q1245	TRANSISTOR, NPN	MOT	2N4428	204428
Q1246	TRANSISTOR, PNP	MOT	2N5160	205160
Q1247	TRANSISTOR, PNP	MOT	2N2905A	202905
Q1248	TRANSISTOR, PNP	MOT	2N5160	205160
Q1249	TRANSISTOR, NPN	MOT	2N4428	204428
Q1263	TRANSISTOR, NPN	MOT	2N3904	203904
Q1287	TRANSISTOR, NPN	MOT	MPS6515	206515
Q1289	TRANSISTOR, PNP	MOT	2N3906	203906
Q1291	TRIAC	TI	T2850D	222850
Q1302	TRANSISTOR, PNP	TI	TIP32A	200032
Q1303	TRANSISTOR, NPN	MOT	2N2219A	202219
Q1312	TRANSISTOR, PNP	MOT	2N2905A	202905
Q1342	TRANSISTOR, NPN	TI	TIP31A	200031
Q1343	TRANSISTOR, NPN	TI	TIP31A	200031
Q1343	TRANSISTOR, NPN	MOT	2N3904	203904
Q1344	TRANSISTOR, PNP	TI	TIP32A	200032
Q1358	TRANSISTOR, PNP	MOT	2N3906	203906
R100	POT 5K	BMK	TYPE72PMR2K	658250
R101	2K 1% 1/4W	PRE	GP1/4W-T100	927220
R102	160 5% 1/2W	PRE	GP1/2W-T100	937116
R105	75 5% 1W	PRE	GP1/4W-T100	947075
R106	150 1% 1/4W	PRE	GP1/4W-T100	928115
R107	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R108	100 1% 1/4W	PRE	GP1/4W-T100	927110
R109	200 1% 1/4W	PRE	GP1/4W-T100	927120
R110	62 5% 1/4W	PRE	GP1/4W-T100	927062
R111	150 10% 2W	PRE	GP2W-T100	958115
R112	75 5% 1/4W	PRE	GP1/4W-T100	927075
R114	POT 100 10%	BMK	TYPE72PMR100	658110
R115	100 10% 1W	PRE	GP1/4W-T100	948110
R116	4.87K 1% 1/4W	PRE	GP1/4W-T100	850248
R117	619 1% 1/4W	PRE	GP1/4W-T100	927162
R118	5.11K 1% 1/4W	PRE	GP1/4W-T100	927251
R119	47.5K 1% 1/4W	PRE	GP1/4W-T100	927347
R120	100 1% 1/4W	PRE	GP1/4W-T100	927110
R121	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R122	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R123	2.2K 10% 1/2W	PRE	GP1/2W-T100	938222
R124	2.43K 1% 1/4W	PRE	GP1/4W-T100	927224
R125	75 5% 1/4W	PRE	GP1/4W-T100	927075
R126	POT 200 10%	BMK	TYPE72PMR200	658121
R127	100 1% 1/4W	PRE	GP1/4W-T100	927110
R128	200 1% 1/4W	PRE	GP1/4W-T100	927120
R129	3.92K 1% 1/4W	PRE	GP1/4W T100	850239
R130	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R131	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R132	47.5 1% 1/4W	PRE	GP1/4W T100	927047
R133	2K 1% 1/2W	PRE	GP1/2W-T100	835220
R134	10K 1% 1/4W	PRE	GP1/4W-T100	850310

SCHEM REF	DESCRIPTION	MFR	MFR PART NUMBER	KH NUMBER
R135	100 1% 1/4W	PRE	GP1/4W-T100	927110
R136	10K 1% 1/4W	PRE	GP1/4W-T100	850310
R137	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R138	200 1% 1/4W	PRE	GP1/4W-T100	927120
R139	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R142	100M 10% 1/4W	PRE	GP1/4W-T100	928710
R143	1.2K 10% 1/2W	PRE	GP1/2W-T100	938212
R144	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R145	100 1% 1/4W	PRE	GP1/4W-T100	927110
R146	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R147	9.1K 5% 1/4W	PRE	GP1/4W-T100	927291
R148	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R149	51.1K 1% 1/4W	PRE	GP1/4W-T100	927351
R150	200 1% 1/4W	PRE	GP1/4W-T100	927120
R151	100 1% 1/4W	PRE	GP1/4W-T100	927110
R152	2K 1% 1/4W	PRE	GP1/4W-T100	927220
R153	3.32K 1% 1/4W	PRE	GP1/4W-T100	927233
R154	100M 10% 1/4W	PRE	GP1/4W-T100	928710
R155	47M 10% 1/4W	PRE	GP1/4W-T100	928647
R156	2K 5% 1/2W	PRE	GP1/2W-T100	937220
R157	221 1% 1/4W	PRE	GP1/4W-T100	928122
R158	2.7K 10% 1/2W	PRE	GP1/2W-T100	938227
R159	24.3 1% 1/4W	PRE	GP1/4W-T100	927024
R160	20K 1% 1/4W	PRE	GP1/4W-T100	927320
R161	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R164	511 1% 1/4W	PRE	GP1/4W-T100	927151
R165	475 1% 1/4W	PRE	GP1/4W-T100	928147
R166	100 1% 1/4W	PRE	GP1/4W-T100	927110
R167	10 1% 1/4W	PRE	GP1/4W-T100	928010
R168	22.1K 1% 1/4W	PRE	GP1/4W-T100	927322
R169	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R170	475 1% 1/4W	PRE	GP1/4W-T100	928147
R171	560 10% 2W	PRE	GP2W-T100	958156
R172	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R173	510 5% 1W	PRE	GP1W-T100	947151
R174	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R175	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R176	91 5% 1/4W	PRE	GP1/4W-T100	927091
R180	10 1% 1/4W	PRE	GP1/4W-T100	928010
R181	10 1% 1/4W	PRE	GP1/4W-T100	928010
R182	10 1% 1/4W	PRE	GP1/4W-T100	928010
R183	10 1% 1/4W	PRE	GP1/4W-T100	928010
R184	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R185	1M 1% 1/4W	PRE	GP1/4W-T100	927510
R186	POT 100K 10%	BMK	TYPE72PMR100K	658410
R187	10K 1% 1/4W	PRE	GP1/4W-T100	850310
R188	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R189	6.04K 1% 1/4W	PRE	GP1/4W-T100	850260
R190	10K 1% 1/4W	PRE	GP1/4W-T100	850310
R191	1M 1% 1/4W	PRE	GP1/4W-T100	927510
R195	2.21K 1% 1/4W	PRE	GP1/4W-T100	927222
R196	POT 200 10%	BMK	TYPE72PMR200	658121
R197	100 1% 1/4W	PRE	GP1/4W-T100	927110
R198	22.1K 1% 1/4W	PRE	GP1/4W-T100	927322
R199	POT 5K	BMK	TYPE72PMR5K	658250
R200	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R201	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R202	18.2K 1% 1/4W	PRE	GP1/4W-T100	927318
R203	3.32K 1% 1/4W	PRE	GP1/4W-T100	927233
R204	221 1% 1/4W	PRE	GP1/4W-T100	928122
R205	232 1% 1/4W	PRE	GP1/4W-T100	850123
R206	232 1% 1/4W	PRE	GP1/4W-T100	850123
R207	100 1% 1/4W	PRE	GP1/4W-T100	927110
R208	POT 100 10%	BMK	TYPE72PMR100	658110
R209	75 5% 1/4W	PRE	GP1/4W-T100	927075
R210	2.43K 1% 1/2W	PRE	M5 T1	835224
R211	2.43K 1% 1/2W	PRE	M5 T1	835224
R212	100 1% 1/4W	PRE	GP1/4W-T100	927110
R213	100 1% 1/4W	PRE	GP1/4W-T100	927110
R214	121 1% 1/4W	PRE	GP1/4W-T100	850112
R215	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R216	2.15K 1% 1/4W	PRE	GP1/4W-T100	850218
R217	121 1% 1/4W	PRE	GP1/4W-T100	850112
R218	100 1% 1/4W	PRE	GP1/4W-T100	927110
R219	100 1% 1/4W	PRE	GP1/4W-T100	927110
R220	147 1% 1/4W	PRE	GP1/4W-T100	850114
R221	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R222	2.26K 1% 1/4W	PRE	GP1/4W-T100	850222A
R223	147 1% 1/4W	PRE	GP1/4W-T100	850114
R224	100 1% 1/4W	PRE	GP1/4W-T100	927110
R225	100 1% 1/4W	PRE	GP1/4W-T100	927110
R226	105 1% 1/4W	PRE	GP1/4W-T100	850110
R227	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R228	3.57K 0.1% 1/4W	PRE	GP1/4W-T100	822236
R229	105 1% 1/4W	PRE	GP1/4W-T100	850110
R230	100 1% 1/4W	PRE	GP1/4W-T100	927110
R231	100 1% 1/4W	PRE	GP1/4W-T100	927110
R232	97.6 1% 1/4W	PRE	GP1/4W-T100	850097
R233	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R234	2.15K 1% 1/4W	PRE	GP1/4W-T100	850218
R235	97.6 1% 1/4W	PRE	GP1/4W-T100	850097
R236	100 1% 1/4W	PRE	GP1/4W-T100	927110
R237	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R238	820 10% 1W	PRE	GP1/4W-T100	948182
R239	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R240	POT 100	AB	3299W-1-101	689110
R241	1.74K 1% 1/2W	PRE	M5 T1	835217
R242	1.74K 1% 1/2W	PRE	M5 T1	835217
R243	255 1% 1/4W	PRE	GP1/4W-T100	850125
R244	619 1% 1/4W	PRE	GP1/4W-T100	927162
R245	2.4.K 5% 1/2W	PRE	GP1/4W-T100	937224
R246	26.7 1% 1/4W	PRE	GP1/4W-T100	928027
R247	2.2K 10% 1/2W	PRE	GP1/4W-T100	938222
R248	100 1% 1/4W	PRE	GP1/4W-T100	927110

SCHEM REF	DESCRIPTION	MFR	MFR PART NUMBER	KH NUMBER
R250	619 1% 1/4W	PRE	GP1/4W-T100	927162
R251	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R252	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R253	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R254	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R255	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R256	619 1% 1/4W	PRE	GP1/4W-T100	927162
R257	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R258	4.75K 1% 1/4W	PRE	GP1/4W-T100	927247
R270	1.0K 0.1% 1/4W	PRE	GP1/4W-T100	822210
R271	2.5K 0.1% 1/4W	PRE	GP1/4W-T100	822225
R272	277.8 0.1% 1/4W	PRE	GP1/4W-T100	822127
R273	267K 1% 1/4W	PRE	GP1/4W-T100	928427
R274	475 1% 1/4W	PRE	GP1/4W-T100	928147
R275	100K 1% 1/4W	PRE	GP1/4W-T100	927410
R276	1.0K 0.1% 1/4W	PRE	GP1/4W-T100	822210
R277	267K 1% 1/4W	PRE	GP1/4W-T100	928427
R278	5.0K 0.1% 1/4W	PRE	GP1/4W-T100	812250
R279	555.6 0.1% 1/4W	PRE	GP1/4W-T100	822154
R280	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R281	100K 1% 1/4W	PRE	GP1/4W-T100	927410
R300	47.5K 1% 1/4W	PRE	GP1/4W-T100	927347
R301	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R302	1.1K 1% 1/4W	PRE	GP1/4W-T100	927211
R303	POT 200 10%	BMK	TYPE72PMR200	658121
R304	23.7K 1% 1/4W	PRE	GP1/4W-T100	850325
R305	51.1K 1% 1/4W	PRE	GP1/4W-T100	927351
R306	POT 100K 10%	BMK	TYPE72PMR100K	658410
R307	POT 100K 10%	BMK	TYPE72PMR100K	658410
R308	470K 10% 1/4W	PRE	GP1/4W-T100	928447
R309	732 0.1% 1/4W	PRE	GP1/4W-T100	822173
R310	8.06K 0.1% 1/4W	PRE	GP1/4W-T100	822280B
R311	73.2K 0.1% 1/4W	PRE	GP1/4W-T100	822373A
R320	470K 10% 1/4W	PRE	GP1/4W-T100	928447
R322	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R323	73.2K 0.1% 1/4W	PRE	GP1/4W-T100	822373A
R324	8.06K 0.1% 1/4W	PRE	GP1/4W-T100	822280B
R325	732 0.1% 1/4W	PRE	GP1/4W-T100	822173
R326	10.0K 0.1% 1/4W	PRE	GP1/4W-T100	812310
R327	10.0K 0.1% 1/4W	PRE	GP1/4W-T100	812310
R335	POT 100 10%	BMK	TYPE72PMR100	658110
R336	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R337	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R338	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R339	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R340	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R341	75K 5% 1/4W	PRE	GP1/4W-T100	927375
R342	75K 5% 1/4W	PRE	GP1/4W-T100	927375
R343	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R344	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R345	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R346	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R347	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R348	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R349	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R350	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R351	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R352	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R353	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R354	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R355	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R356	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R357	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R358	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R359	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R360	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R400	POT 20K	AB	68WR20K	655320
R401	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R402	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R403	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R404	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R405	7.5K 1% 1/4W	PRE	GP1/4W-T100	927275
R406	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R407	511 1% 1/4W	PRE	GP1/4W-T100	927151
R408	511 1% 1/4W	PRE	GP1/4W-T100	927151
R409	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R410	100 1% 1/4W	PRE	GP1/4W-T100	927110
R412	3.01K 1% 1/4W	PRE	GP1/4W-T100	927230
R413	3.01K 1% 1/4W	PRE	GP1/4W-T100	927230
R414	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R415	15K 1% 1/4W	PRE	GP1/4W-T100	927315
R417	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R418	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R419	2.7 10% 1/4W	PRE	GP1/4W-T100	928927
R420	4.99K 1% 1/4W	PRE	GP1/4W-T100	850249
R421	7.5K 1% 1/4W	PRE	GP1/4W-T100	927275
R422	5.49K 1% 1/4W	PRE	GP1/4W-T100	850254
R423	2.7 10% 1/4W	PRE	GP1/4W-T100	928927
R424	511 1% 1/4W	PRE	GP1/4W-T100	927151
R425	91 5% 1/4W	PRE	GP1/4W-T100	927091
R426	91 5% 1/4W	PRE	GP1/4W-T100	927091
R429	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R430	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R431	100 1% 1/4W	PRE	GP1/4W-T100	927110
R432	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R433	15K 1% 1/4W	PRE	GP1/4W-T100	927315
R434	2K 1% 1/4W	PRE	GP1/4W-T100	927220
R435	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R436	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R438	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R439	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R441	100 1% 1/4W	PRE	GP1/4W-T100	927110
R442	POT 200 10%	BMK	TYPE72PMR200	658121
R443	221 1% 1/4W	PRE	GP1/4W-T100	928122

SCHEM REF	DESCRIPTION	MFR	MFR PART NUMBER	KH NUMBER
R444	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R445	3.2K 0.1% 1/4W	PRE	GP1/4W-T100	822232
R446	5.49K 1% 1/4W	PRE	GP1/4W-T100	850254
R447	2.7 10% 1/4W	PRE	GP1/4W-T100	928927
R448	511 1% 1/4W	PRE	GP1/4W-T100	927151
R449	91 5% 1/4W	PRE	GP1/4W-T100	927091
R450	91 5% 1/4W	PRE	GP1/4W-T100	927091
R458	200 1% 1/4W	PRE	GP1/4W-T100	927120
R459	200 1% 1/4W	PRE	GP1/4W-T100	927120
R460	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R461	511 1% 1/4W	PRE	GP1/4W-T100	927151
R462	2.7 10% 1/4W	PRE	GP1/4W-T100	928927
R463	4.75K 1% 1/4W	PRE	GP1/4W-T100	927247
R464	100 1% 1/4W	PRE	GP1/4W-T100	927110
R465	2.67K 1% 1/4W	PRE	GP1/4W-T100	927227
R466	2K 1% 1/4W	PRE	GP1/4W-T100	927210
R467	4.32K 1% 1/4W	PRE	GP1/4W-T100	927243
R468	130K 1% 1/4W	PRE	GP1/4W-T100	927413
R469	182K 1% 1/4W	PRE	GP1/4W-T100	928412
R470	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R471	5.11K 1% 1/4W	PRE	GP1/4W-T100	927251
R472	91 5% 1/4W	PRE	GP1/4W-T100	927091
R473	511 1% 1/4W	PRE	GP1/4W-T100	927151
R474	511 1% 1/4W	PRE	GP1/4W-T100	927151
R475	511 1% 1/4W	PRE	GP1/4W-T100	927151
R476	2.7 10% 1/4W	PRE	GP1/4W-T100	928927
R477	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R478	150 1% 1/4W	PRE	GP1/4W-T100	928115
R479	24.9K 1% 1/4W	PRE	GP1/4W-T100	850324
R480	24.9K 1% 1/4W	PRE	GP1/4W-T100	850324
R481	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R482	150 1% 1/4W	PRE	GP1/4W-T100	928115
R483	221 1% 1/4W	PRE	GP1/4W-T100	928122
R484	POT 200 10%	BMK	TYPE72PMR200	658121
R485	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R486	2.851K 0.1% 1/4W	PRE	GP1/4W-T100	822229
R487	5.49K 1% 1/4W	PRE	GP1/4W-T100	850254
R488	511 1% 1/4W	PRE	GP1/4W-T100	927151
R489	2.7 10% 1/4W	PRE	GP1/4W-T100	928927
R490	91 5% 1/4W	PRE	GP1/4W-T100	927091
R500	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R501	511 1% 1/4W	PRE	GP1/4W-T100	927151
R502	511 1% 1/4W	PRE	GP1/4W-T100	927151
R503	511 1% 1/4W	PRE	GP1/4W-T100	927151
R504	2.7 10% 1/4W	PRE	GP1/4W-T100	928927
R505	511 1% 1/4W	PRE	GP1/4W-T100	927151
R506	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R507	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R508	511 1% 1/4W	PRE	GP1/4W-T100	927151
R509	511 1% 1/4W	PRE	GP1/4W-T100	927151
R510	2.7 10% 1/4W	PRE	GP1/4W-T100	928927
R511	91 5% 1/4W	PRE	GP1/4W-T100	927091
R512	511 1% 1/4W	PRE	GP1/4W-T100	927151
R513	91 5% 1/4W	PRE	GP1/4W-T100	927091
R514	511 1% 1/4W	PRE	GP1/4W-T100	927151
R515	2.7 10% 1/4W	PRE	GP1/4W-T100	928927
R516	91 5% 1/4W	PRE	GP1/4W-T100	927091
R517	91 5% 1/4W	PRE	GP1/4W-T100	927091
R518	511 1% 1/4W	PRE	GP1/4W-T100	927151
R519	511 1% 1/4W	PRE	GP1/4W-T100	927151
R520	511 1% 1/4W	PRE	GP1/4W-T100	927151
R521	2.7 10% 1/4W	PRE	GP1/4W-T100	928927
R522	91 5% 1/4W	PRE	GP1/4W-T100	927091
R523	91 5% 1/4W	PRE	GP1/4W-T100	927091
R530	4.75K 1% 1/4W	PRE	GP1/4W-T100	927247
R531	4.75K 1% 1/4W	PRE	GP1/4W-T100	927247
R532	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R533	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R534	165K 1% 1/4W	PRE	GP1/4W-T100	850416
R535	11.8K 1% 1/4W	PRE	GP1/4W-T100	850311A
R536	100K 1% 1/4W	PRE	GP1/4W-T100	927410
R537	100K 1% 1/4W	PRE	GP1/4W-T100	927410
R538	100K 1% 1/4W	PRE	GP1/4W-T100	927410
R545	26.7K 1% 1/4W	PRE	GP1/4W-T100	928327
R546	26.7K 1% 1/4W	PRE	GP1/4W-T100	928327
R547	1M 1% 1/4W	PRE	GP1/4W-T100	927510
R548	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R549	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R550	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R551	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R552	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R553	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R554	1M 1% 1/4W	PRE	GP1/4W-T100	927510
R555	2K 1% 1/4W	PRE	GP1/4W-T100	927220
R556	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R557	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R558	3.01K 1% 1/4W	PRE	GP1/4W-T100	927230
R559	4.02K 1% 1/4W	PRE	GP1/4W-T100	850240
R560	6.04K 1% 1/4W	PRE	GP1/4W-T100	850260
R561	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R562	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R563	3.01K 1% 1/4W	PRE	GP1/4W-T100	927230
R564	301 1% 1/4W	PRE	GP1/4W-T100	850130
R565	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R566	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R567	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R568	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R569	5.49M 1% 1/4W	PRE	GP1/4W-T100	850554
R570	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R571	100K 1% 1/4W	PRE	GP1/4W-T100	927410
R572	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R573	3.01K 1% 1/4W	PRE	GP1/4W-T100	927230
R574	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R575	10M 1% 1/2W	PRE	GP1/2W-T100	850610

SCHEM REF	DESCRIPTION	MFR	MFR PART NUMBER	KH NUMBER
R576	100K 1% 1/4W	PRE	GP1/4W-T100	927410
R577	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R578	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R585	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R586	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R587	1.3K 1% 1/4W	PRE	GP1/4W-T100	927213
R588	1.3K 1% 1/4W	PRE	GP1/4W-T100	927213
R589	47.5K 1% 1/4W	PRE	GP1/4W-T100	927347
R590	47.5K 1% 1/4W	PRE	GP1/4W-T100	927347
R591	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R592	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R593	511 1% 1/4W	PRE	GP1/4W-T100	927151
R594	9.53K 1% 1/4W	PRE	GP1/4W-T100	850295
R595	POT 1K	BMK	TYPE72PMR1K	658210
R596	511 1% 1/4W	PRE	GP1/4W-T100	927151
R597	200 1% 1/4W	PRE	GP1/4W-T100	927120
R598	200 1% 1/4W	PRE	GP1/4W-T100	927120
R599	374 1% 1/4W	PRE	GP1/4W-T100	850137
R600	2.7 10% 1/4W	PRE	GP1/4W-T100	928927
R601	121 1% 1/4W	PRE	GP1/4W-T100	928112
R602	142.3 1% 1/4W	PRE	GP1/4W-T100	825114
R603	495 1% 1/4W	PRE	GP1/4W-T100	825149
R604	2.7 10% 1/4W	PRE	GP1/4W-T100	928927
R605	91 5% 1/4W	PRE	GP1/4W-T100	927091
R606	200 1% 1/4W	PRE	GP1/4W-T100	927120
R607	511 1% 1/4W	PRE	GP1/4W-T100	927151
R608	1.65K 1% 1/4W	PRE	GP1/4W-T100	850216A
R609	511 1% 1/4W	PRE	GP1/4W-T100	927151
R610	1 10% 1/2W	PRE	GP1/2W-T100	938910
R611	1.62K 1% 1/4W	PRE	GP1/4W-T100	927216
R620	3.32K 1% 1/4W	PRE	GP1/4W-T100	927233
R621	5.11K 1% 1/4W	PRE	GP1/4W-T100	927251
R622	5.11K 1% 1/4W	PRE	GP1/4W-T100	927251
R623	5.11K 1% 1/4W	PRE	GP1/4W-T100	927251
R624	5.11K 1% 1/4W	PRE	GP1/4W-T100	927251
R625	5.11K 1% 1/4W	PRE	GP1/4W-T100	927251
R627	3.32K 1% 1/4W	PRE	GP1/4W-T100	927233
R628	3.32K 1% 1/4W	PRE	GP1/4W-T100	927233
R634	5.62K 1% 1/4W	PRE	GP1/4W-T100	927256
R635	4.75K 1% 1/4W	PRE	GP1/4W-T100	927247
R636	2.67K 1% 1/4W	PRE	GP1/4W-T100	927227
R638	20K 1% 1/4W	PRE	GP1/4W-T100	927320
R800	51.1K 1% 1/4W	PRE	GP1/4W-T100	927351
R801	51.1K 1% 1/4W	PRE	GP1/4W-T100	927351
R802	51.1K 1% 1/4W	PRE	GP1/4W-T100	927351
R803	51.1K 1% 1/4W	PRE	GP1/4W-T100	927351
R812	267 1% 1/4W	PRE	GP1/4W-T100	928127
R813	267 1% 1/4W	PRE	GP1/4W-T100	928127
R814	267 1% 1/4W	PRE	GP1/4W-T100	928127
R815	267 1% 1/4W	PRE	GP1/4W-T100	928127
R816	267 1% 1/4W	PRE	GP1/4W-T100	928127
R817	267 1% 1/4W	PRE	GP1/4W-T100	928127
R818	267 1% 1/4W	PRE	GP1/4W-T100	928127
R819	267 1% 1/4W	PRE	GP1/4W-T100	928127
R820	681 1% 1/4W	PRE	GP1/4W-T100	928168
R821	681 1% 1/4W	PRE	GP1/4W-T100	928168
R822	681 1% 1/4W	PRE	GP1/4W-T100	928168
R823	681 1% 1/4W	PRE	GP1/4W-T100	928168
R824	681 1% 1/4W	PRE	GP1/4W-T100	928168
R825	681 1% 1/4W	PRE	GP1/4W-T100	928168
R826	681 1% 1/4W	PRE	GP1/4W-T100	928168
R827	681 1% 1/4W	PRE	GP1/4W-T100	928168
R828	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R829	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R830	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R831	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R832	51.1K 1% 1/4W	PRE	GP1/4W-T100	927351
R833	51.1K 1% 1/4W	PRE	GP1/4W-T100	927351
R834	51.1K 1% 1/4W	PRE	GP1/4W-T100	927351
R835	51.1K 1% 1/4W	PRE	GP1/4W-T100	927351
R836	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R837	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R838	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R839	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R840	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R841	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R842	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R843	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R850	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R851	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R852	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R853	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R854	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R855	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R856	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R857	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R858	221 1% 1/4W	PRE	GP1/4W-T100	928122
R859	5.11K 1% 1/4W	PRE	GP1/4W-T100	927251
R860	POT 1K	BMK	TYPE 72PMR1K	658210
R861	POT 1K	BMK	TYPE 72PMR1K	658210
R870	1.5K 1% 1/4W	PRE	GP1/4W-T100	927215
R871	1.5K 1% 1/4W	PRE	GP1/4W-T100	927215
R872	1.5K 1% 1/4W	PRE	GP1/4W-T100	927215
R873	100K 1% 1/4W	PRE	GP1/4W-T100	927410
R875	100K 1% 1/4W	PRE	GP1/4W-T100	927410
R876	100K 1% 1/4W	PRE	GP1/4W-T100	927410
R878	5.11K 1% 1/4W	PRE	GP1/4W-T100	927251
R879	POT 25K 10%	BMK	TYPE 72PMR25K	658325
R880	8.2K 1% 1/4W	PRE	GP1/4W-T100	927282
R881	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R882	5.11K 1% 1/4W	PRE	GP1/4W-T100	927251
R883	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R884	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R885	243K 1% 1/4W	PRE	GP1/4W-T100	927424

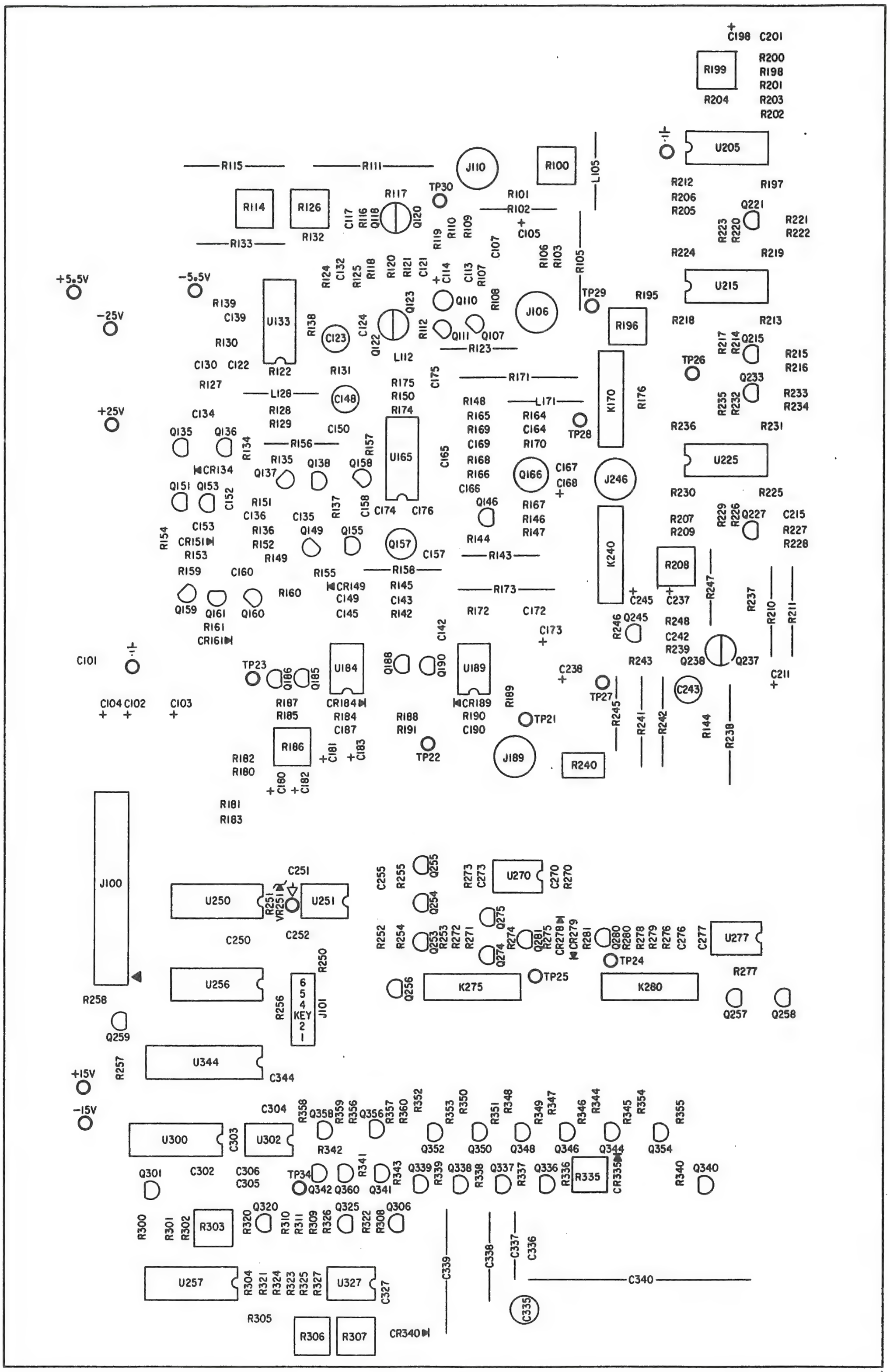
SCHEM REF	DESCRIPTION	MFR	MFR PART NUMBER	KH NUMBER
R886	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R887	2K 1% 1/4W	PRE	GP1/4W-T100	927220
R888	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R900	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R901	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R902	5.0K 0.1% 1/4W	PRE	GP1/4W-T100	812250
R903	5.0K 0.1% 1/4W	PRE	GP1/4W-T100	812250
R904	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R905	100K 1% 1/4W	PRE	GP1/4W-T100	927410
R906	1M 1% 1/4W	PRE	GP1/4W-T100	927510
R907	11K 1% 1/4W	PRE	GP1/4W-T100	927311
R908	11K 1% 1/4W	PRE	GP1/4W-T100	927311
R909	100K 1% 1/4W	PRE	GP1/4W-T100	927410
R910	1M 1% 1/4W	PRE	GP1/4W-T100	927510
R911	600 1% 1/4W	PRE	GP1/4W-T100	825160
R912	320 0.5% 1/4W	PRE	GP1/4W-T100	823132
R913	1.1K 1% 1/4W	PRE	GP1/4W-T100	927211
R914	1.1K 1% 1/4W	PRE	GP1/4W-T100	927211
R915	100K 1% 1/4W	PRE	GP1/4W-T100	927410
R916	100K 1% 1/4W	PRE	GP1/4W-T100	927410
R917	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R918	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R919	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R920	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R921	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R922	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R923	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R924	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R925	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R926	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R927	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R928	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R929	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R930	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R931	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R932	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R933	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R934	51.1K 1% 1/4W	PRE	GP1/4W-T100	927351
R935	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R936	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R937	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R938	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R939	51.1K 1% 1/4W	PRE	GP1/4W-T100	927351
R950	100 1% 1/4W	PRE	GP1/4W-T100	927110
R951	7.5K 1% 1/4W	PRE	GP1/4W-T100	927275
R952	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R953	750 1% 1/2W	PRE	GP1/2-T100	835175
R954	750 1% 1/2W	PRE	GP1/2-T100	835175
R955	182 1% 1/4W	PRE	GP1/4W-T100	927118
R956	432 1% 1/4W	PRE	GP1/4W-T100	927143
R957	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R958	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R959	750 1% 1/2W	PRE	GP1/2-T100	835175
R960	750 1% 1/2W	PRE	GP1/2-T100	835175
R961	91 5% 1/4W	PRE	GP1/4W-T100	927091
R962	31.6 1% 1/4W	PRE	GP1/4W-T100	850031
R963	31.6 1% 1/4W	PRE	GP1/4W-T100	850031
R964	31.6 1% 1/4W	PRE	GP1/4W-T100	850031
R965	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R966	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R967	150 1% 1/4W	PRE	GP1/4W-T100	928115
R968	100 1% 1/4W	PRE	GP1/4W-T100	927110
R969	75 5% 1W	PRE	GP1/4W-T100	947075
R970	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R971	158.4 .5% 1W	AB	ORWOT	844115
R972	POT 5K	BMK	TYPE72PMR5K	658250
R973	2K 1% 1/4W	PRE	GP1/4W-T100	927220
R974	232 1% 1/4W	PRE	GP1/4W-T100	850123
R975	62 5% 1/4W	PRE	GP1/4W-T100	927062
R976	4.7 10% 1/4W	PRE	GP1/4W-T100	928947
R977	119.4 1% 3/4W	PRE	M6 T1	895111
R978	75 5% 1/4W	PRE	GP1/4W-T100	927075
R979	2.74K 1% 1/4W	PRE	GP1/4W-T100	850227
R980	POT 100 10%	BMK	TYPE72PMR100	658110
R981	119.4 1% 3/4W	PRE	M6 T1	895111
R989	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R990	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R991	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R993	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R994	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R995	91 5% 1/4W	PRE	GP1/4W-T100	927091
R996	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R997	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R998	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R999	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1000	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1001	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1002	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1003	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1004	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1005	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1006	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1007	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1008	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1009	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R1020	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R1021	475 1% 1/4W	PRE	GP1/4W-T100	825147
R1022	475 1% 1/4W	PRE	GP1/4W-T100	825147
R1023	3.01K 1% 1/4W	PRE	GP1/4W-T100	927230
R1024	51.1K 1% 1/4W	PRE	GP1/4W-T100	927351
R1025	2K 1% 1/4W	PRE	GP1/4W-T100	927220
R1026	475 1% 1/4W	PRE	GP1/4W-T100	825147
R1027	2K 1% 1/4W	PRE	GP1/4W-T100	927220
R1028	100 1% 1/4W	PRE	GP1/4W-T100	927110

SCHEM REF	DESCRIPTION	MFR	MFR PART NUMBER	KH NUMBER
R1029	100 1% 1/4W	PRE	GP1/4W-T100	927110
R1030	POT 1K	BMK	TYPE72PMR1K	658210
R1031	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1050	12.1K 1% 1/4W	PRE	GP1/4W-T100	927312
R1051	47.5K 1% 1/4W	PRE	GP1/4W-T100	927347
R1052	22.1K 1% 1/4W	PRE	GP1/4W-T100	927322
R1053	47.5K 1% 1/4W	PRE	GP1/4W-T100	927347
R1054	2.0K 0.1% 1/4W	PRE	GP1/4W-T100	822220
R1055	5.11K 1% 1/4W	PRE	GP1/4W-T100	927251
R1056	47.5K 1% 1/4W	PRE	GP1/4W-T100	927347
R1057	12.1K 1% 1/4W	PRE	GP1/4W-T100	927312
R1058	2.0K 0.1% 1/4W	PRE	GP1/4W-T100	822220
R1059	2K 1% 1/4W	PRE	GP1/4W-T100	927220
R1060	POT 100K 10%	BMK	TYPE72XWR100K	658411
R1061	100K 1% 1/4W	PRE	GP1/4W-T100	927410
R1062	91 5% 1/4W	PRE	GP1/4W-T100	927091
R1063	91 5% 1/4W	PRE	GP1/4W-T100	927091
R1064	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1065	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1066	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1067	1.2K 10% 1W	PRE	GP1/4W-T100	948212
R1068	12.1K 1% 1/4W	PRE	GP1/4W-T100	927312
R1069	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1070	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1071	33.2K 1% 1/4W	PRE	GP1/4W-T100	850333
R1072	33.2K 1% 1/4W	PRE	GP1/4W-T100	850333
R1073	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1074	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1075	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1076	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1077	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1078	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1079	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1080	2.7K 0.1% 1/4W	PRE	GP1/4W-T100	822227
R1081	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1082	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1083	960 0.1% 1/4W	PRE	GP1/4W-T100	822196
R1084	5.11K 1% 1/4W	PRE	GP1/4W-T100	927251
R1085	2.21K 1% 1/4W	PRE	GP1/4W-T100	850222
R1086	1.0K 0.1% 1/4W	PRE	GP1/4W-T100	822210
R1087	10 1% 1/4W	PRE	GP1/4W-T100	928010
R1088	1.78K 1% 1/4W	PRE	GP1/4W-T100	850217
R1089	10 1% 1/4W	PRE	GP1/4W-T100	928010
R1090	22.1K 1% 1/4W	PRE	GP1/4W-T100	927322
R1091	100 1% 1/4W	PRE	GP1/4W-T100	927110
R1092	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R1093	511 1% 1/4W	PRE	GP1/4W-T100	927151
R1094	619 1% 1/4W	PRE	GP1/4W-T100	850161
R1095	1K 1% 1W	AB	P-1A	745210
R1096	3.01K 1% 1/4W	PRE	GP1/4W-T100	927230
R1097	POT 1K	BKM	TYPE72XWR1K	658211
R1098	6.98K 1% 1/4W	PRE	GP1/4W-T100	850269
R1099	15K 1% 1/4W	PRE	GP1/4W-T100	927315
R1100	243K 1% 1/4W	PRE	GP1/4W-T100	927424
R1101	POT 25K 10%	BKM	TYPE72XWR25K	658326
R1102	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1103	4.75K 1% 1/4W	PRE	GP1/4W-T100	927247
R1104	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1105	4.75K 1% 1/4W	PRE	GP1/4W-T100	927247
R1106	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1107	4.75K 1% 1/4W	PRE	GP1/4W-T100	927247
R1110	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1111	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1112	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1113	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1114	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1115	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1116	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1117	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1118	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1119	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1120	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1121	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1122	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1123	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1124	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1125	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1126	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1127	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1128	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1129	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1130	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1131	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1132	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1133	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1134	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1135	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1136	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1137	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1138	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1139	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1140	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1141	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1142	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1143	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1144	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1145	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1146	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1147	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1148	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1149	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1150	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1151	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1152	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324

SCHEM REF	DESCRIPTION	MFR	MFR PART NUMBER	KH NUMBER
R1153	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1160	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1161	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1162	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1163	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1164	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1165	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1166	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1167	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1168	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1169	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1170	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1171	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1172	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1173	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1174	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1175	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1176	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1177	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1178	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1179	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1180	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1181	10M 1% 1/2W	PRE	GP1/2W-T100	850610
R1185	277.8 0.1% 1/4W	PRE	GP1/4W-T100	822127
R1186	301 1% 1/4W	PRE	GP1/4W-T100	927130
R1187	150 0.1% 1/4W	PRE	GP1/4W-T100	822115
R1188	277.8 0.1% 1/4W	PRE	GP1/4W-T100	822127
R1189	150 0.1% 1/4W	PRE	GP1/4W-T100	822115
R1190	277.8 0.1% 1/4W	PRE	GP1/4W-T100	822127
R1191	150 0.1% 1/4W	PRE	GP1/4W-T100	822115
R1192	277.8 0.1% 1/4W	PRE	GP1/4W-T100	822127
R1193	150 0.1% 1/4W	PRE	GP1/4W-T100	822115
R1194	277.8 0.1% 1/4W	PRE	GP1/4W-T100	822127
R1195	150 0.1% 1/4W	PRE	GP1/4W-T100	822115
R1196	277.8 0.1% 1/4W	PRE	GP1/4W-T100	822127
R1197	150 0.1% 1/4W	PRE	GP1/4W-T100	822115
R1198	277.8 0.1% 1/4W	PRE	GP1/4W-T100	822127
R1199	150 0.1% 1/4W	PRE	GP1/4W-T100	822115
R1200	277.8 0.1% 1/4W	PRE	GP1/4W-T100	822127
R1201	150 0.1% 1/4W	PRE	GP1/4W-T100	822115
R1202	277.8 0.1% 1/4W	PRE	GP1/4W-T100	822127
R1203	150 0.1% 1/4W	PRE	GP1/4W-T100	822115
R1204	277.8 0.1% 1/4W	PRE	GP1/4W-T100	822127
R1205	40.67 0.1% 1/4W	PRE	GP1/4W-T100	822040
R1206	389 0.5% 1/4W	AB	GP1/4W-T100	823136
R1210	POT 25K 10%	BKM	TYPE72XWR25K	658326
R1211	100K 1% 1/4W	PRE	GP1/4W-T100	927410
R1212	511 1% 1/4W	PRE	GP1/4W-T100	927151
R1213	2.7 10% 1/4W	PRE	GP1/4W-T100	928927
R1214	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R1215	2.21K 1% 1/4W	PRE	GP1/4W-T100	850222
R1216	1.82K .1% 1/2W	PRE	GP1/2-T100	832218
R1217	1.82K .1% 1/2W	PRE	GP1/2-T100	832218
R1218	560 10% 1W	PRE	GP1/4W-T100	948156
R1219	POT 200 10%	BMK	TYPE72PMR200	658121
R1220	1.3K 1% 1/4W	PRE	GP1/4W-T100	927213
R1221	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R1222	2K 1% 1/4W	PRE	GP1/4W-T100	927220
R1223	POT 200 10%	BMK	TYPE72PMR200	658121
R1224	100 1% 1/4W	PRE	GP1/4W-T100	927110
R1225	10 1% 1/4W	PRE	GP1/4W-T100	928010
R1226	511 1% 1/4W	PRE	GP1/4W-T100	927151
R1230	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R1231	475 1% 1/4W	PRE	GP1/4W-T100	928147
R1232	4.53K 1% 1/4W	PRE	GP1/4W-T100	850245
R1233	1.07K 1% 1/4W	PRE	GP1/4W-T100	850210
R1234	44.2 1% 1/4W	PRE	GP1/4W-T100	850044
R1236	33.2 1% 1/4W	PRE	GP1/4W-T100	927033
R1237	10 1% 1/4W	PRE	GP1/4W-T100	928010
R1238	10 1% 1/4W	PRE	GP1/4W-T100	928010
R1239	47.5 1% 1/4W	PRE	GP1/4W-T100	927047
R1240	1.0K 0.1% 1/4W	PRE	GP1/4W-T100	822210
R1241	340 1% 1/2W	PRE	GP1/2-T100	835134
R1243	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R1244	10 1% 1/4W	PRE	GP1/4W-T100	928010
R1245	15 1% 1/4W	PRE	GP1/4W-T100	928015
R1246	15 1% 1/4W	PRE	GP1/4W-T100	928015
R1247	10 1% 1/4W	PRE	GP1/4W-T100	928010
R1248	15 1% 1/4W	PRE	GP1/4W-T100	928015
R1249	15 1% 1/4W	PRE	GP1/4W-T100	928015
R1250	78.36 .5% 1W	AB	ORWOT	844078
R1251	78.36 .5% 1W	AB	ORWOT	844078
R1252	392 1% 1/4W	PRE	GP1/4W-T100	850138
R1253	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R1254	2K 1% 1W	AB	KM-100	745220
R1260	470 5% 2W	PRE	GP1/4W-T100	957147
R1261	56.2 1% 1/4W	PRE	GP1/4W-T100	928056
R1262	24.3K 1% 1/4W	PRE	GP1/4W-T100	927324
R1263	4.75K 1% 1/4W	PRE	GP1/4W-T100	927247
R1264	POT 100 10%	BMK	TYPE72PMR100	658110
R1265	100 1% 1/4W	PRE	GP1/4W-T100	927110
R1266	390.6 0.1% 1/2W	PRE	GP1/2W-T100	822140
R1267	POT 1K	BMK	TYPE72PMR1K	658210
R1268	5.0K 0.1% 1/4W	PRE	GP1/4W-T100	812250
R1269	5.0K 0.1% 1/4W	PRE	GP1/4W-T100	812250
R1270	10.0K 0.1% 1/4W	PRE	GP1/4W-T100	812310
R1271	825 1% 1/4W	PRE	GP1/4W-T100	850182
R1275	2.383K 0.5% 1/4W	PRE	GP1/4W-T100	823223
R1276	3.32K 1% 1/4W	PRE	GP1/4W-T100	927233
R1277	39.84 0.5% 1/4W	PRE	GP1/4W-T100	823039
R1278	124.8 .5% 1W	MAL	ORWOT	844112
R1279	124.8 .5% 1W	MAL	ORWOT	844112
R1280	46.1 0.5% 1/4W	PRE	GP1/4W-T100	823046
R1281	511 1% 1/4W	PRE	GP1/4W-T100	927151

SCHEM REF	DESCRIPTION	MFR	MFR PART NUMBER	KH NUMBER
R1282	235.9 .5% 1/2W	PRE	GP1/2-T100	844123
R1283	158.4 .5% 1W	MAL	ORWOT	844115
R1284	158.4 .5% 1W	MAL	ORWOT	844115
R1285	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R1286	619K 1% 1/4W	PRE	GP1/4W-T100	927462
R1287	10 1% 1/4W	PRE	GP1/4W-T100	928010
R1288	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R1289	619K 1% 1/4W	PRE	GP1/4W-T100	927462
R1290	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R1291	.82 5% 1W	PRE	P-1A	747908
R1301	225 5% 5W	AB	P-5	777123
R1302	3.32K 1% 1/4W	PRE	GP1/4W-T100	927233
R1303	390 5% 1/2W	PRE	GP1/2W-T100	937139
R1304	100 1% 1/4W	PRE	GP1/4W-T100	927110
R1305	3.32K 1% 1/4W	PRE	GP1/4W-T100	927233
R1306	100 1% 1/4W	PRE	GP1/4W-T100	927110
R1307	3.32K 1% 1/4W	PRE	GP1/4W-T100	927233
R1308	390 5% 1/2W	PRE	GP1/2W-T100	937139
R1309	3.32K 1% 1/4W	PRE	GP1/4W-T100	927233
R1310	225 5% 5W	AB	P-5	777123
R1311	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R1312	30.0K 0.1% 1/4W	PRE	GP1/4W-T100	822330
R1313	10.0K 0.1% 1/4W	PRE	GP1/4W-T100	812310
R1314	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R1315	POT 5K 10%	BMK	TYPE72XWR5K	658251
R1316	16.2K 1% 1/4W	PRE	GP1/4W-T100	927316
R1317	6.49K 1% 1/4W	PRE	GP1/4W-T100	850264
R1318	16.2K 0.1% 1/4W	PRE	GP1/4W-T100	822316
R1319	9.72K 0.1% 1/4W	PRE	GP1/4W-T100	822297
R1320	10K 1% 1/4W	PRE	GP1/4W-T100	927310
R1340	1 10% 1/2W	PRE	GP1/4W-T100	938910
R1341	1 10% 1/2W	PRE	GP1/2W-T100	938910
R1342	200 1% 1W	KM	KM-100	745120
R1343	24.3 1% 1/4W	PRE	GP1/4W-T100	927024
R1344	330 10% 1/2W	PRE	GP1/2W-T100	938133
R1345	1 10% 1/2W	PRE	GP1/2W-T100	938910
R1346	1 10% 1/2W	PRE	GP1/2W-T100	938910
R1347	20K 1% 1/4W	PRE	GP1/4W-T100	927320
R1348	20K 1% 1/4W	PRE	GP1/4W-T100	927320
R1349	9.72K 0.1% 1/4W	PRE	GP1/4W-T100	822297
R1350	2.74K 0.1% 1/4W	PRE	GP1/4W-T100	822228
R1351	9.72K 0.1% 1/4W	PRE	GP1/4W-T100	822297
R1355	2.74K 0.1% 1/4W	PRE	GP1/4W-T100	822228
R1357	681 1% 1/4W	PRE	GP1/4W-T100	928168
R1357	681 1% 1/4W	PRE	GP1/4W-T100	928168
R1359	1K 1% 1/4W	PRE	GP1/4W-T100	927210
R1360	15K 1% 1/4W	PRE	GP1/4W-T100	927315
S400	SWITCH SLIDE	UID	SW422-SOPC	346615
S800	SWITCH TYPE SRV	DST	TYPE SRV	344083
S801	SWITCH TYPE SRV	DST	TYPE SRV	344083
S802	SWITCH TYPE SRV	DST	TYPE SRV	344083
S803	SWITCH TYPE SRV	DST	TYPE SRV	344083
S804	SWITCH TYPE SRV	DST	TYPE SRV	344083
S805	SWITCH TYPE SRV	DST	TYPE SRV	344083
S806	SWITCH TYPE SRV	DST	TYPE SRV	344083
S807	SWITCH TYPE SRV	DST	TYPE SRV	344083
S808	SWITCH TYPE SRV	DST	TYPE SRV	344083
S809	SWITCH TYPE SRV	DST	TYPE SRV	344083
S810	SWITCH TYPE SRV	DST	TYPE SRV	344073
S811	SWITCH TYPE SRV	DST	TYPE SRV	344083
S812	SWITCH TYPE SRV	DST	TYPE SRV	344083
S813	SWITCH TYPE SRV	DST	TYPE SRV	344083
S814	SWITCH TYPE SRV	DST	TYPE SRV	344083
S815	SWITCH TYPE SRV	DST	TYPE SRV	344083
S816	SWITCH TYPE SRV	DST	TYPE SRV	344083
S817	SWITCH TYPE SRV	DST	TYPE SRV	344083
S818	SWITCH TYPE SRV	DST	TYPE SRV	344073
S819	SWITCH TYPE SRV	DST	TYPE SRV	344083
S820	SWITCH TYPE SRV	DST	TYPE SRV	344073
S821	SWITCH TYPE SRV	DST	TYPE SRV	344073
S822	SWITCH TYPE SRV	DST	TYPE SRV	344073
S824	SWITCH TYPE SRV	DST	TYPE SRV	344073
S825	SWITCH TYPE SRV	DST	TYPE SRV	344073
S826	SWITCH TYPE SRV	DST	TYPE SRV	344073
S827	SWITCH TYPE SRV	DST	TYPE SRV	344073
S828	SWITCH TYPE SRV	DST	TYPE SRV	344073
S829	SWITCH TYPE SRV	DST	TYPE SRV	344073
S830	SWITCH TYPE SRV	DST	TYPE SRV	344083
S831	SWITCH TYPE SRV	DST	TYPE SRV	344072
S832	SWITCH TYPE SRV	DST	TYPE SRV	344083
S834	SWITCH TYPE SRV	DST	TYPE SRV	344073
S835	SWITCH TYPE SRV	DST	TYPE SRV	344073
S836	SWITCH TYPE SRV	DST	TYPE SRV	344083
S837	SWITCH TYPE SRV	DST	TYPE SRV	344083
S838	SWITCH TYPE SRV	DST	TYPE SRV	344083
S1000	SWITCH SLIDE	SW	46206LFR	346404B
S1001	SWITCH SLIDE	SW	46206LFR	346404B
S1002	SWITCH	SW	8280K27H	346535
S1003	SWITCH SLIDE	CWI	GF 123	345014
T1000	TRANSFORMER	TT	C4156	361031
U133	IC	RCA	CA3102E	223102
U165	IC TRANSISTOR ARRAY	MOT	MPQ2369	202369Q
U184	IC OPAMP	NTL	NE5534AN	265534
U189	IC OPAMP	NTL	NE5534AN	265534
U205	IC TRANSISTOR ARRAY	MOT	MPQ918	200918

SCHEM REF	DESCRIPTION	MFR	MFR PART NUMBER	KH NUMBER
U215	IC TRANSISTOR ARRAY	AB	MPQ918	200918
U225	IC TRANSISTOR ARRAY	MOT	MPQ918	200918
U250	IC	NTL	AD7524JN	287524
U251	IC OPAMP	NTL	NE5534AN	265534
U256	IC HEX D FLIP-FLOP	MOT	MC14174BCP	204174
U257	IC 4 TO 10 LINE DECODER	MOT	MC14028BCP	204028
U270	IC OPAMP	NTL	LF356N	200356
U277	IC OPAMP	NTL	LF356N	200356
U300	IC	NTL	AD7524JN	287524
U302	IC OPAMP	NTL	NE5534AN	265534
U327	IC	NAT	LF13741N	213741N
U344	IC OCTAL LATCH	MOT	MC74HC374	204374
U405	IC HEX INVERTER	NTL	SN74HC04	207404A
U406	IC DUAL D FLIP-FLOP	MOT	MC74HC74N	207474A
U409	RESISTOR ARRAY	MOT	316B101	860101
U410	IC	MOT	MC145145P	201451
U412	IC OPAMP	NTL	LF356N	200356
U420	IC	MOT	MC1658P	201658
U430	RESISTOR ARRAY	MOT	316B101	860101
U431	IC	MOT	MC145145P	201451
U435	IC OPAMP	NTL	LF356N	200356
U445	IC	MOT	MC1658P	201658
U460	IC	MOT	MC10137P	201013A
U466	IC	MOT	MC10137P	201013A
U470	IC	MOT	MC12040	201204
U480	IC OPAMP	NTL	NE5534AN	265534
U485	IC	MOT	MC1658P	201658
U500	IC	MOT	MC10231P	201023
U510	IC	MOT	MC12040	201204
U515	IC	MOT	MC10116P	201011
U520	IC	MOT	MC10116P	201011
U530	IC 12 BIT DAC	AD	AD667JN	280667
U538	IC 4 TO 10 LINE DECODER	MOT	MC14028BCP	204028
U545	IC HEX D FLIP-FLOP	MOT	MC14174BCP	204174
U560	IC OPAMP	NTL	NE5534AN	265534
U565	IC OPAMP	NTL	NE5534AN	265534
U570	IC	NAT	LF13741N	213741N
U585	IC OPAMP	NTL	NE5534AN	265534
U600	IC	MOT	MC12040	201204
U605	IC	MOT	MC10137P	201013A
U610	IC	MOT	MC10137P	201013A
U620	IC GPIB BUFFER	MOT	MC3448AP	203448
U621	IC GPIB BUFFER	MOT	MC3448AP	203448
U622	IC GPIB BUFFER	MOT	MC3448AP	203448
U623	IC GPIB BUFFER	MOT	MC3448AP	203448
U624	IC QUAD 2 INPUT NAND GATE	NTL	SN74LS00N	207400A
U626	IC GPIB INTERFACE	MOT	MC68B488P	208488A
U627	IC MPU, 2MHZ	MOT	MC68B02P	206802A
U628	IC	MAN	R6522AP	286522A
U629	IC EPROM, 8K X 8	DAL	D2764A	202764
U630	IC 3 TO 8 LINE DECODER	NTL	SN74LS138N	204138
U631	IC EPROM, 8K X 8	DAL	D2764A	202764
U634	IC EPROM, 8K X 8	DAL	D2764A	202764
U635	IC EPROM, 8K X 8	DAL	D2764A	202764
U636	IC PIA, 2MHZ	MOT	MC68B21P	206821A
U637	IC HEX TRISTATE	MOT	MC14503BCP	201450
U638	IC RAM, 8K X 8 NON-VOLATILE	DAL	DS1225	261225
U800	IC 4 TO 10 LINE DECODER	NTL	SN74145	204145
U813	DISPLAY GREEN	MAN	MAN6460	296460
U815	IC 4 TO 10 LINE DECODER	NTL	SN74145	204145
U817	DISPLAY GREEN	MAN	MAN6460	296460
U821	DISPLAY GREEN	MAN	MAN6460	296460
U825	DISPLAY GREEN	MAN	MAN6460	296460
U829	DISPLAY GREEN	MAN	MAN6460	296460
U832	DISPLAY GREEN	MAN	MAN6460	296460
U833	DISPLAY GREEN	MAN	MAN6460	296460
U850	IC	NTL	SN74S163	204163
U851	IC OCTAL LATCH	MOT	MC74HC374	204374
U852	IC 4 BIT SYNC. COUNTER	MOT	MC74HC161	204161A
U853	IC 4 BIT SYNC. COUNTER	MOT	MC74HC161	204161A
U854	IC 4 BIT SYNC. COUNTER	MOT	MC74HC161	204161A
U855	IC 4 BIT SYNC. COUNTER	MOT	MC74HC161	204161A
U856	IC OCTAL D TRANSPARENT LATCH	NTL	SN74S573N	204573
U857	IC HEX D FLIP-FLOP	NTL	SN74HC174	204174B
U858	IC DAC	AD	AD565KD	280565
U859	IC HEX D FLIP-FLOP	NTL	SN74HC174	204174B
U860	IC OCTAL D TRANSPARENT LATCH	NTL	SN74S573N	204573
U861	IC OCTAL D TRANSPARENT LATCH	NTL	SN74S573N	204573
U870	IC 4 TO 10 LINE DECODER	MOT	MC14028BCP	204028
U871	IC OCTAL LATCH	MOT	MC74HC374	204374
U872	IC OCTAL LATCH	MOT	MC74HC374	204374
U873	IC OCTAL LATCH	MOT	MC74HC374	204374
U874	IC 4 BIT SYNC. COUNTER	MOT	MC74HC161	204161A
U875	IC 4 BIT SYNC. COUNTER	MOT	MC74HC161	204161A
U876	IC 4 BIT SYNC. COUNTER	MOT	MC74HC161	204161A
U877	IC 4 BIT SYNC. COUNTER	MOT	MC74HC161	204161A
U878	IC DUAL D FLIP-FLOP	MOT	MC74HC74N	207474A
U879	IC DUAL D FLIP-FLOP	MOT	MC74HC74N	207474A
U880	IC DUAL LINE RECEIVER	NTL	SN75107AN	265107
U881	IC HEX INVERTER	NTL	SN74HC04	207404A
U882	IC HEX INVERTER	NTL	SN74HC04	207404A
U886	IC OPAMP	NTL	LF356N	200356
U902	IC OPAMP	NTL	LF356N	200356
U910	IC OPAMP	NTL	LF356N	200356
U990	IC QUAD 2 INPUT NOR GATE	MOT	MC14001BP	204001
U1009	IC	NTL	SN74S74	207474B
U1085	IC	RCA	CA3102E	223102
U1102	IC HEX D FLIP-FLOP	MOT	MC14174BCP	204174
U1103	IC OCTAL LATCH	MOT	MC74HC374	204374
U1104	IC HEX D FLIP-FLOP	MOT	MC14174BCP	204174
U1105	IC 4 TO 10 LINE DECODER	MOT	MC14028BCP	204028
U1215	IC TRANSISTOR ARRAY	MOT	MPQ2369	202369Q
U1264	IC	NTL	AD7524JN	287524
U1268	IC OPAMP	NTL	NE5534AN	265534
U1270	IC OPAMP	NTL	NE5534AN	265534
U1308	IC OPAMP	NTL	NE5534AN	265534
U1314	IC OPAMP	NTL	NE5534AN	265534
U1332	IC REGULATOR, POS 15V	NTL	MC7815CP	207815
U1333	IC REGULATOR, NEG 15V	NTL	MC7915CP	207915
U1345	IC OPAMP	NTL	NE5534AN	265534
U1346	IC OPAMP	NTL	NE5534AN	265534
VR251	DIODE ZENER 10V	CST	1N961B	230961
VR1213	DIODE ZENER 10V	CST	1N961B	230961
VR1217	DIODE ZENER 15V	CST	1N965B	230965
VR1222	DIODE ZENER 15V	CST	1N965B	230965
VR1243	DIODE ZENER 4.3V	CST	1N749A	280749
VR1253	DIODE ZENER 4.3V	CST	1N749A	280749
VR1271	DIODE ZENER 9V 20PPM/C	CST	1N937B	230937
VR1307	DIODE ZENER 6.8V	CST	1N957B	230957
VR1312	DIODE ZENER 4.3V	CST	1N749A	280749
VR1314	DIODE ZENER 6.4V	CD	1N4577A	264577
VR1316	DIODE ZENER 18V	CST	1N967B	230967
VR1213A	DIODE ZENER 10V	CST	1N961B	230961
VR1217A	DIODE ZENER 15V	CST	1N965B	230965
VR1222A	DIODE ZENER 15V	CST	1N965B	230965
VR1243A	DIODE ZENER 4.3V	CST	1N749A	280749
VR1253A	DIODE ZENER 4.3V	CST	1N749A	280749
VR1271A	DIODE ZENER 9V 20PPM/C	CST	1N937B	230937
X1000	RECEPTACLE AC WITH LINE FILTER	KH	029031	029031
Y400	CRYSTAL OSCILLATOR	MOT	K1518AF	026011
Y627	CRYSTAL 8MHZ 20PPM ACCURACY	MOT	MP-1	290800



C198 C201
R199
R200 R198 R201 R203 R202
R204
U205
R115 R111 J110 R100 L105
R212 R206 R205 R197
Q221 R221 R222
R114 R126 R117 TP30 R101 R102 C105
R132 R133
R223 R220
R224 R219
+5.5V -5.5V -25V +25V
U215
TP29 R195
R196 J106 U133
R218 R213
Q110 Q111 Q107 R123
L112 C123 C148 L128
R139 C139 R130 C130 C122 R122 R127 R131
TP26 Q215 Q233
R215 R216 R233 R234
R171 L171 K170 R176
R175 R150 R174 R128 R129
C134 Q135 Q136 C150 R156
R148 R165 R169 C169 R168 R166 C166
R164 C164 R170 TP28
R236 R231
U225 U165
Q166 J246 C167 C168
R135 Q138 Q158 Q137
CR134 Q151 Q153 C152
R151 C136 R136 R152 R149
C135 Q149 Q155 Q157 C157
C174 C176 Q146
R167 R146 R147 R144 R143
R230 R225
R207 R209 Q227 C215 R227 R228
K240 R208
C153 CR151 R153 R154
R159 C160 R155 R158
Q159 Q161 Q160 R160
CR149 C149 C145 R145 C143 R142
R173 R172 C172 C173
C245 C237 R247 R237 R210 R211
R161 CR161
Q245 R246 R248 C242 R239 R243
Q238 Q237 C211
C101 TP23 U184 U189
C142 Q188 Q190
C238 TP27 C243
C104 C102 C103
R187 R185 CR184 R184 C187
CR189 R190 C190 R189
R188 R191 TP21
R245 R241 R242 R144 R238
R186 C181 C183 TP22 J189 R240
R182 R180 C180 C182
R181 R183
J100
C251 U250 R251 VR251 U251
C255 R255 Q255 Q254
R273 C273 U270 C270 R270
C250 C252
R252 R254 Q253 R253 R272 R271 Q274 R274 Q275 Q281 R275 CR278 CR279 R281 Q280 R280 R278 R279 R276 C276 C277
U277 TP24 R277
R250 U256 J101 KEY 6 5 4 2 1
R256 R258
Q256 K275 TP25 K280
Q257 Q258 Q259
R257 U344 C344
+15V -15V
C304 R358 Q358 R359 R356 Q356 R357 R360 R352 R353 R350 R351 R348 R349 R347 R346 R344 R345 R354 R355
U300 C303 U302
R342 Q352 Q350 Q348 Q346 Q344 Q354
Q301 C302 C306 C305 TP34 Q342 Q360 R341 Q341 R343
Q339 R339 Q338 R338 Q337 R337 Q336 R336 R335 CR335 R340 Q340
Q320 Q325 Q306
R300 R301 R302 R303 R320 R310 R311 R309 R326 R322 R308
C339 C338 C337 C336 C340
U257 R304 R321 R324 R323 R325 R327 U327 C327
C335
R305 R306 R307 CR340

PC2100-1

HYSTERESIS FLIP FLOP

TRIANGLE BUFFER

SINE SHAPER

SINE BUFFER

-VC AMP

+VC AMP

TO PC2100-1 PART 2

TO J850 ROM SYNTH BOARD PC2100-5 PART 1

TO J963 ROM SYNTH BOARD PC2100-5 PART 2

TO PC2100-1 PART 2

FROM PLL BOARD PC2100-2 J560

TO J1062 WAVEFORM SWITCHING OF OUTPUT BOARD PC2100-6 J246

MAIN GENERATOR BOARD PART 1

TP30 DC LEVEL

TP30 AMPLITUDE

TP28 DC LEVEL

TP21 30MH VOLTAGE

TP21 3MHz VOLTAGE

HF SINE DISTORTION

HF SINE AMPLITUDE

HF SINE DC LEVEL

HF SINE RESPONSE

SUBSTRATE

-3±3V±0±3 VARIES WITH FREQUENCY SETTING

+3±3V±0±3 VARIES WITH FREQUENCY SETTING

-2±0V+0±2V VARIES WITH FREQUENCY SETTING

TITLE	MAIN GENERATOR BOARD
TOLERANCES	FRACTIONS ±, DECIMALS ±, ANGLES ±
MODEL	2100A
DRAWN	G. Hebert 5-26-87
SCALE	
APP. BY	10-5-87
DWG. NO.	PC2100-1 PART 1
REV.	
SHEET	OF

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KROHN-HITE CORPORATION, AVON, MASS. U.S.A.

MAIN GENERATOR BOARD PART 2

TITLE	MAIN GENERATOR BOARD
DRAWING NO.	2100A
DRN BY	G. Weber 5-14-87
CHK BY	P.C. Kelley 10-2-87
APP BY	P.C. Kelley 5-21-91
ENGR NO.	3446
PROJ NO.	PC2100-1 PART 2
SHEET	

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PC2100-2

DIVIDE BY 4

REFERENCE

NOTE: ONLY ONE REFERENCE USED.
* Y401 OPTIONAL HIGH STABILITY REFERENCE

LOW 4 DIG PLL

SUM PLL

DIVIDE BY 2 AND MIXER

FREQUENCY DETECTOR

TOP 3 DIG PPL

UNLOCKED FREQUENCY DAC

PLL DECODER

PLL LATCH

OUTPUT PLL

PHASE LOCK LOOP

DIVIDE BY 1, 10, 100

DIVIDE BY 1 OR 10

DIVIDE BY 1 OR 10

DATA BUS A

TITLE	PHASE LOCK LOOP
DRAWN	S. Hebert 3-12-87
SCALE	
APP. BY	W. C. Huber 10-2-87
DWG. NO.	PC2100-2
REV.	
DATE	4-24-88
SHEET	

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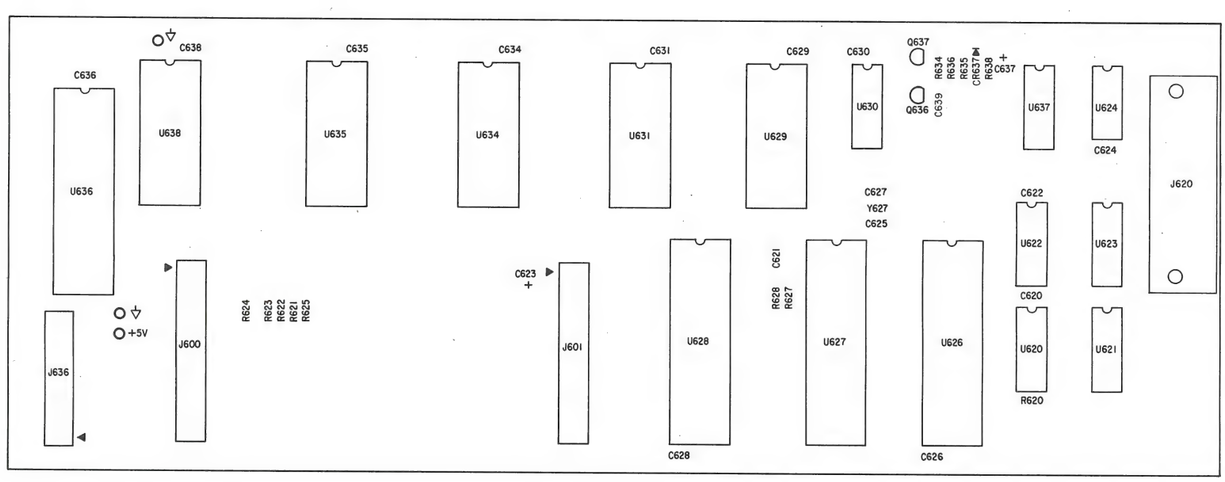
C638
C635
C634
C631
C629
C630
Q637
C636
U638
U635
U634
U631
U629
U630
R634
R636
R635
C633
R638
C637
U637
U624
C624
U636
Q636
C639
J620
C627
Y627
C625
C622
U622
U623
C620
C623
C621
R628
R627
U620
U621
R620
+5V
R624
R623
R622
R621
R625
J636
J600
J601
U628
U627
U626
C628
C626

PC2100-3

J620 IEEE-488 CONNECTOR

U620 MC3448P

U621 MC3448P

U622 MC3448P

U623 MC3448P

U626 MC68B488P

U627 MC68B02

U628 MPS6522AP

U629 2764D E000H

U631 2764D C000H

U634 2764D A000H

U635 2764D 8000H

U636 MC68B21

U637 SN74S03

U638 DS1225 8K X BRAM 0000H

U630 SN74LS138

I/4 U624 74LS00

I/4 U624 74LS00

J600 MAIN RIBBON CABLE CONNECTOR

J601 OPTO ISOLATOR CONNECTOR

J636 TO J600 FRONT PANEL PC2100-4

MICROPROCESSOR BOARD

TITLE	MICROPROCESSOR BOARD
SIZE	2100A
DRN	G.Hebert 5-5-87
SCALE	
APP. BY	10-2-87
DWG. NO.	PC2100-3
REV.	
SHEET	

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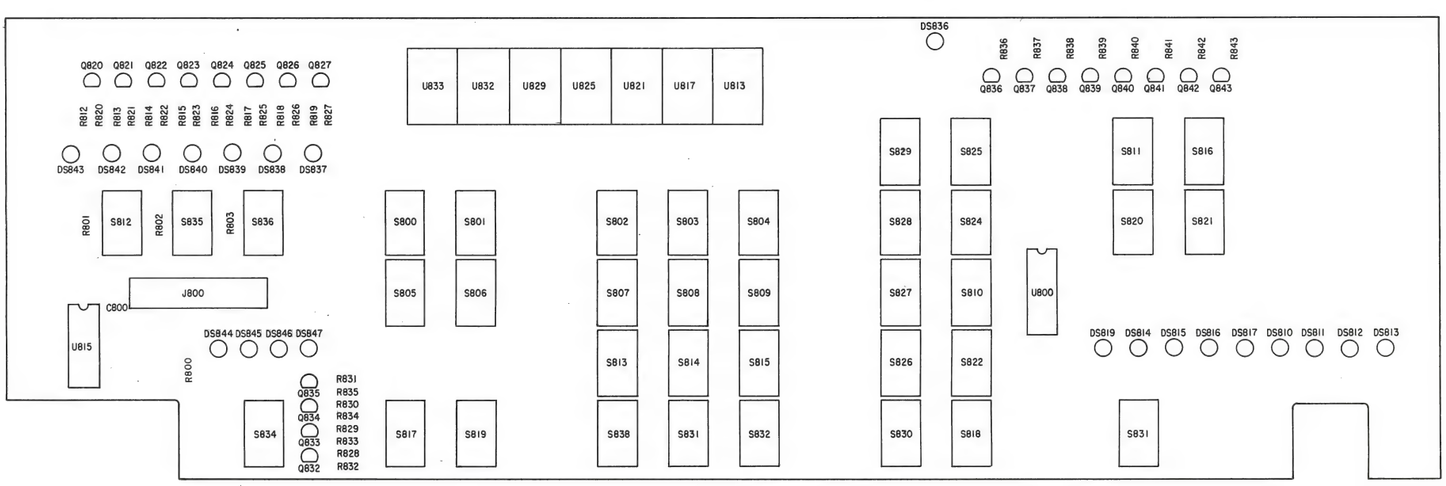
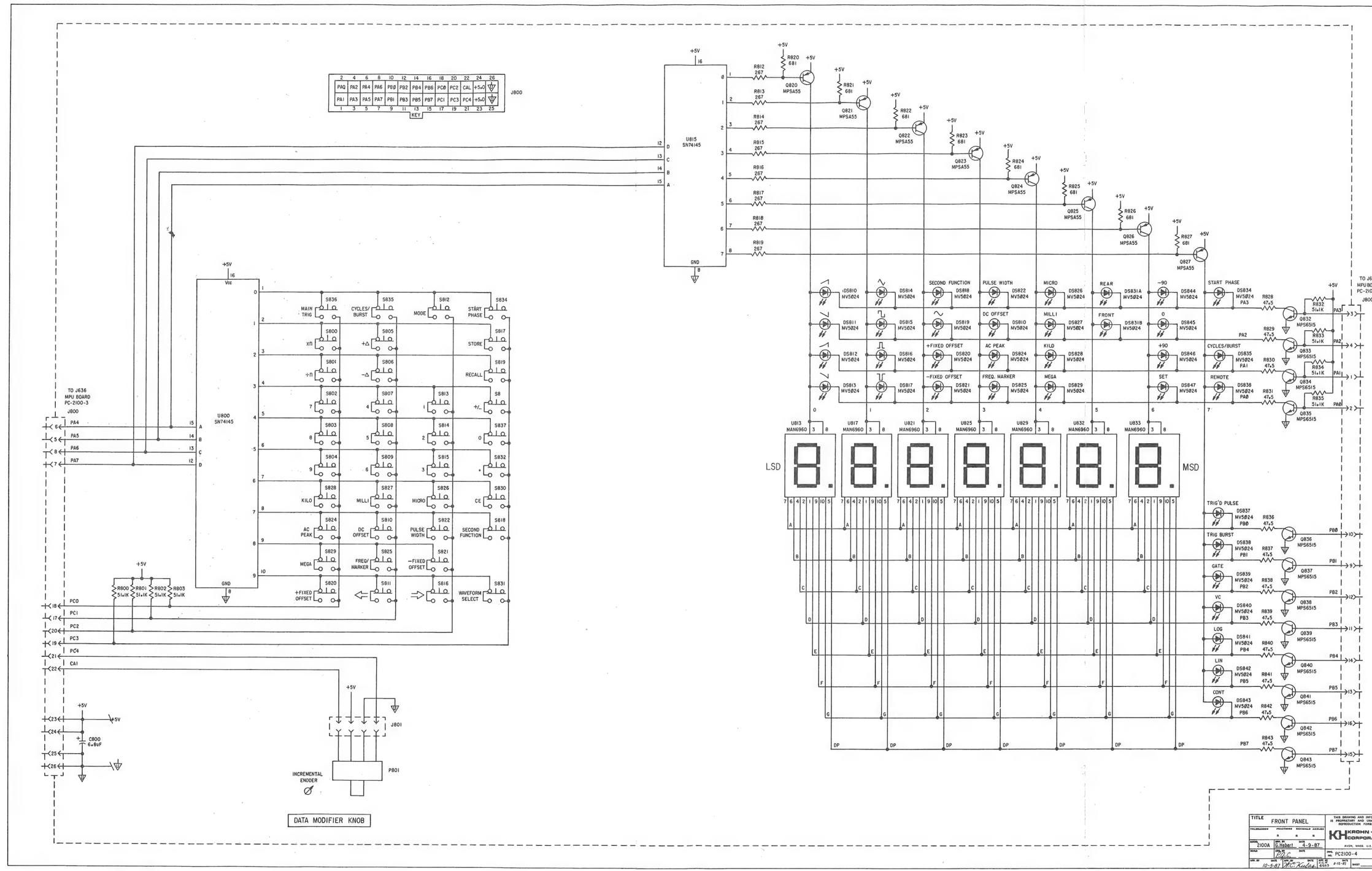
KROHN-HITE CORPORATION
AVON, MASS. U.S.A.


DS836
Q836 Q837 Q838 Q839 Q840 Q841 Q842 Q843
R836 R837 R838 R839 R840 R841 R842 R843
Q820 Q821 Q822 Q823 Q824 Q825 Q826 Q827
R812 R820 R813 R821 R814 R822 R815 R823 R816 R824 R817 R825 R818 R826 R819 R827
DS843 DS842 DS841 DS840 DS839 DS838 DS837
U833 U832 U829 U825 U821 U817 U813
R801 R802 R803
S812 S835 S836
S800 S801 S802 S803 S804
S805 S806 S807 S808 S809
S813 S814 S815
S838 S831 S832
S817 S819
S829 S825 S828 S824 S827 S810 S826 S822 S830 S818
S811 S816 S820 S821
S831
U800
J800
C800
U815
R800
DS844 DS845 DS846 DS847
DS819 DS814 DS815 DS816 DS817 DS810 DS811 DS812 DS813
Q835 Q834 Q833 Q832
R831 R835 R830 R834 R829 R833 R828 R832
S834

PC2100-4


J800
U815 SN74145
U800 SN74145
TO J636 MPU BOARD PC-2100-3
J800
MAIN TRIG
CYCLES/ BURST
MODE
START PHASE
STORE
RECALL
+/-
CE
WAVEFORM SELECT
SECOND FUNCTION
PULSE WIDTH
AC PEAK
DC OFFSET
KILO
MILLI
MICRO
MEGA
FREQ/ MARKER
-FIXED OFFSET
+FIXED OFFSET
R800 51±1K
R801 51±1K
R802 51±1K
R803 51±1K
C800 6.8uF
J801
P801
INCREMENTAL ENCODER
DATA MODIFIER KNOB
LSD
MSD
REAR
FRONT
-90
+90
SET
REMOTE
TRIG'D PULSE
TRIG BURST
GATE
VC
LOG
LIN
CONT
R828 47.5
R829 47.5
R830 47.5
R831 47.5
R832 51±1K
R833 51±1K
R834 51±1K
R835 51±1K
R836 47.5
R837 47.5
R838 47.5
R839 47.5
R840 47.5
R841 47.5
R842 47.5
R843 47.5
Q832 MPS6515
Q833 MPS6515
Q834 MPS6515
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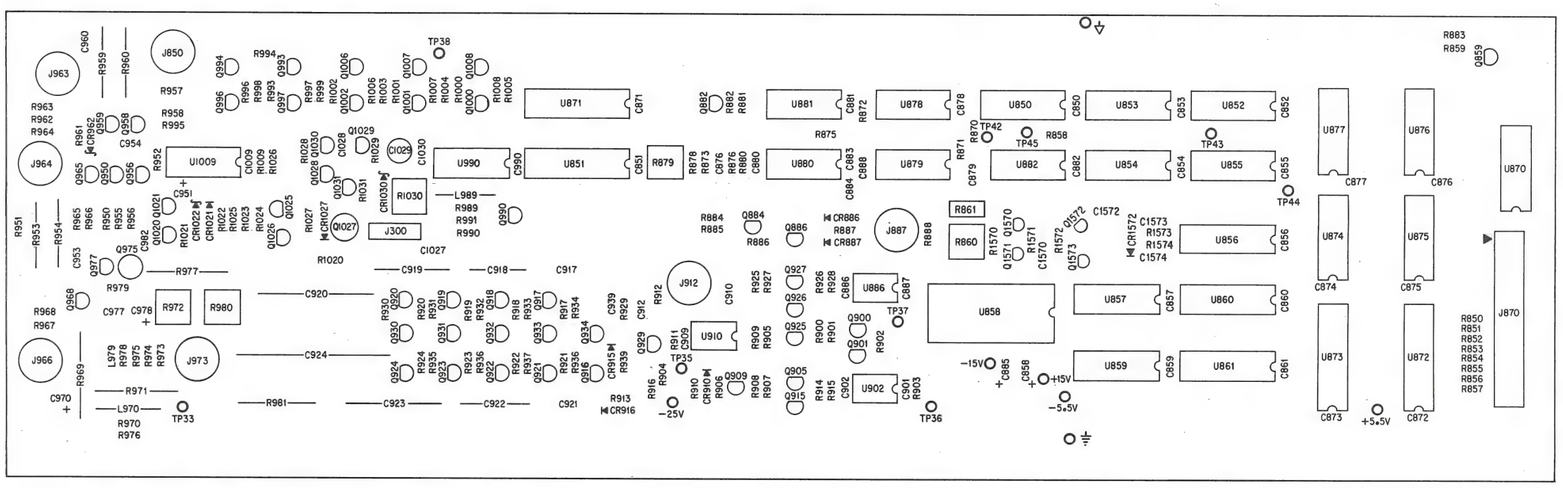
Q836 MPS6515
Q837 MPS6515
Q838 MPS6515
Q839 MPS6515
Q840 MPS6515
Q841 MPS6515
Q842 MPS6515
Q843 MPS6515
FRONT PANEL
TITLE
FRONT PANEL
KRONN-HITE CORPORATION
AVON, MASS. U.S.A.
2100A
G.Hebert 4-9-87
PC2100-4
10-5-87 Mike Kelley
2845 8-12-87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-5V
+15V
-15V
-25V
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Q999

÷ 4 OR ÷ 16 PRESCALER

÷ 1 OR ÷ 250 COUNTERS

POINT ADDRESS COUNTERS

WAVEFORM DATA ROM'S

WAVEFORM DATA LATCHES

WAVEFORM DAC

FROM J106 MAIN GEN PC2100-1 PART 1 F IN

J850

TO TRIG INPUT SWITCHING OF PULSE GEN Q1006 PART 2

U850 74S163

U853 MC74HC161

U854 MC74HC161

U855 MC74HC161

U852 MC74HC161

U856 DM74S573N

U857 SN74HC174

U858 AD565KD

U859 DM74S573N

U860 SN74HC174

U861 DM74S573N

1/6 U882 74HC04

R858 221

Q859 MPS3646

R859 5.11K

TP45

TP37

R860 1K

R861 1K

C885 6.8uF

C886 .1uF

C887 .1uF

C858 6.8uF

LF WAVEFORM AMPLITUDE

DC LEVEL

TO OUTPUT FILTER OF PART 2

LSB

MSB

DATA BUS A

DATA BUS B

ROM SYNTH LATCH

U851 MC74HC374

TO FILTER SELECT OF PART 2

LF WAVEFORM SELECT SEE DATA CHART

MSB DATA LATCH OUTPUT TO Q1007 PULSE GENERATOR OF PART 2

ROM SYNTH DECODER

U870 MC14028B

STROBE

R850 1K

R851 1K

R852 1K

R853 1K

R854 1K

R855 1K

R856 1K

R857 1K

A0

A1

A2

A3

A4

A5

A6

A7

J870

KEY

RIBBON EDGE STRIPE END

+5.4 CONT. OR GATED ON Ø WHEN GATED OFF

TP43

POINT COUNTER DISABLE

+5.4V

TP42

WAVEFORM POINT CLOCK

TP44

BURST CYCLE COUNT ENABLE

ROM SYNTH LATCH

U871 MC74HC374

÷ SELECT H = ÷10^3 L = ÷10^6

TO SQUARE WAVE CONTROL AND PULSE SELECT OF PART 2

TO INVERT SELECT OF PART 2

TO PULSE TRIGGER DRIVE SELECT OF PART 2

GATE TRIG SELLECT +5.5V FOR TRIG MODES AND FREQUENCIES ABOVE 30KH , ØV FOR ALL OTHERS

HOLD POINT COUNTERS

HOLD POINT LATCH

U872 MC74HC374

U875 MC74HC161

U876 MC74HC161

HOLD POINT ENABLE

HOLD DISABLE

HOLD DISABLE FLIP FLOP

1/2 U878 MC74HC74

1/2 U879 MC74HC74

C878 .1uF

C879 .1uF

R870 1.5K

TO Q950 SQUARE GEN LF DRIVE INPUT OF PART 2

BURST LATCH

U873 MC74HC374

U874 MC74HC161

U877 MC74HC161

BURST COUNTERS

EXTERNAL TRIG TO Q1008 PULSE GEN TRIG SWITCHING OF PART 2

U880 SN75107A

1/6 U881 74HC04

R871 1.5K

R872 1.5K

C883 .1uF

R873 100K

C888 2pF

R875 100K

R876 100K

C889 2pF

R878 5.11K

R879 25K

TRIGGER LEVEL

C880 10pF

R880 8.25K

R881 10K

Q882 2N3906

R882 5.1K

R883 1K

Q884 2N5087

R884 240K

R886 10M

R885 240K

-25V

Q886 MPF4392

CR886 IN4149

CR887 IN4149

R887 2K

R888 10K

J887

TRIGGER INPUT BNC J888

U851 LF WAVEFORM CHART

Q7	Q6	WAVEFORM
0	0	∿
0	1	∿
1	0	⟋
1	1	⟋

WAVEFORM POINT CLOCK

MC74HC04

MC74HC74

J870 TC TRIGGER CONTROL FROM IEEE CHIP

ROM SYNTHESIZER GEN BD

TITLE ROM SYNTHESIZER GEN

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KROHN-HITE CORPORATION AVON, MASS U.S.A.

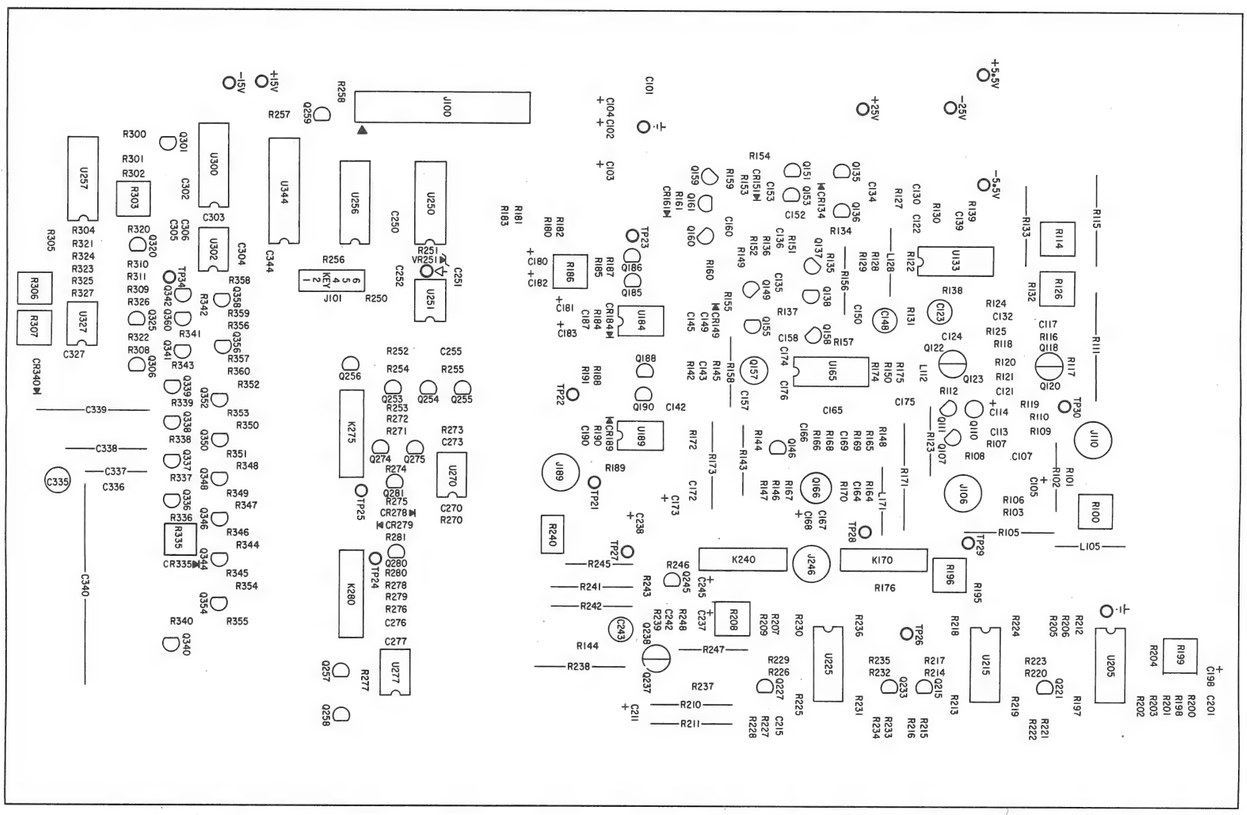
MODEL 2100A DRN BY G.Hobart DATE 5-15-67

SCALE DES.ENG. DATE

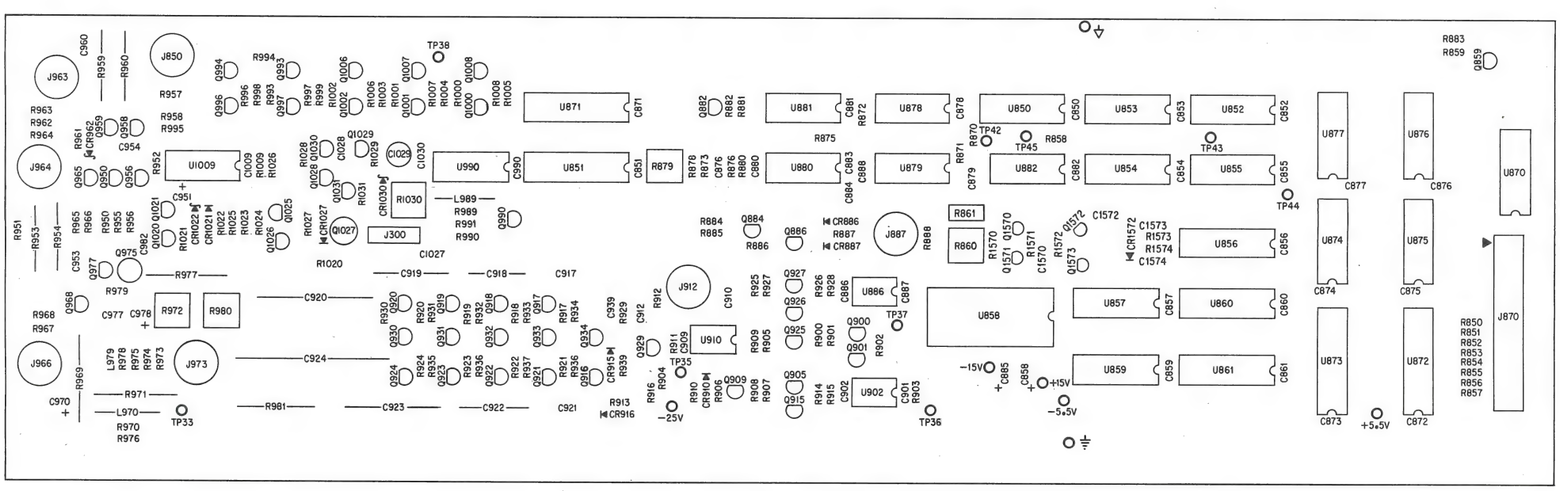
APP. BY 10-5-67 DATE MFG APP. DATE 10-23-67 QA APP. DATE 10-23-67

DWG. NO. PC2100-5 PART 1 REV.

SHEET



PC2100-1



PC2100-5

LF SINE WAVE FILTER

PULSE SQUARE WAVE AND TTL OUTPUT DRIVER

PULSE WIDTH DAC

PULSE WIDTH CURRENT SOURCE

PULSE GEN MONOSTABLE FLIP-FLOP

PULSE RANGE LATCH

CIRCUITRY WITHIN DOTTED LINES IS PART OF THE MAIN GENERATOR BOARD PC2100-1

ROM SYNTHESIZER GEN & PULSE PORTION OF MAIN GEN BD PART 2

TITLE ROM SYNTHESIZER GEN & PULSE PORTION OF MAIN GEN BD

KH KROHN-HITE CORPORATION AVON, MASS. U.S.A.

PC2100-5 PART 2

PC2100-6

OUTPUT AMPLITUDE CONTROL

OUTPUT AMPLIFIER

WAVEFORM BUFFER

AMPLITUDE LATCH

WAVEFORM LATCH

MAIN OUTPUT DECODED

DC OFFSET DAC

dB OUTPUT ATTENUATOR

MAIN OUTPUT

DATA BUS A

DATA BUS B

* MPF4391 SELECTED FOR 20Ω±1Ω DRAIN TO SOURCE ON OHMS WITH 10MEG PULL UP TO +5 VOLTS ON GATE.

TITLE MAIN OUTPUT

KROHN-HITE CORPORATION

MODEL 2100A

DWG. NO. 6.1M0811

DATE 4-9-87

PC 2100-6

DRAWN BY

DATE

CHK. BY 1/4/91

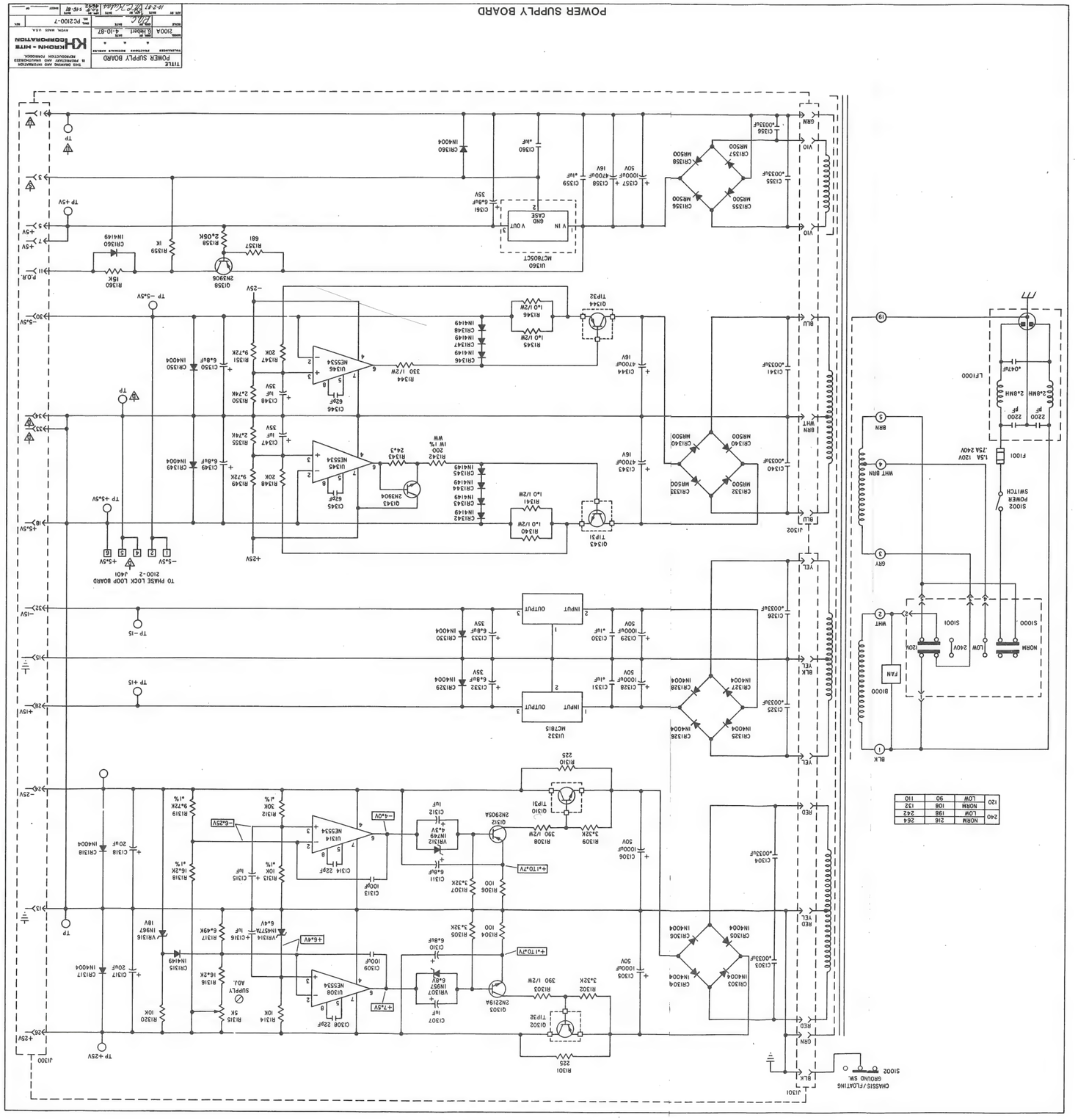
DATE

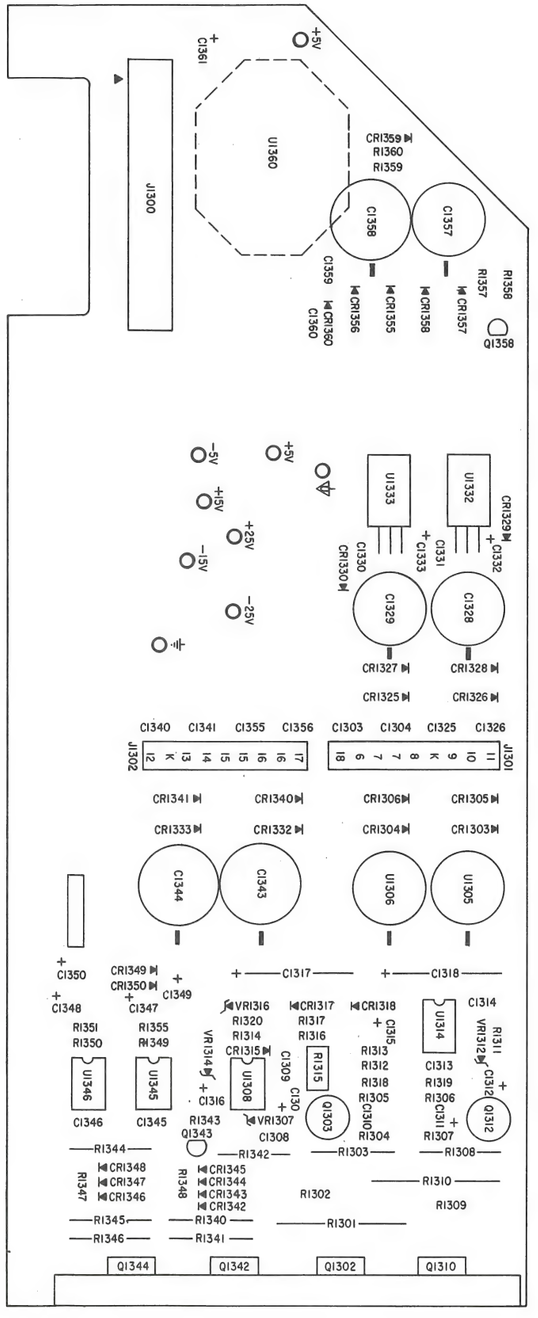
APP. BY

DATE

SCALE

SHEET

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+15V
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-5V
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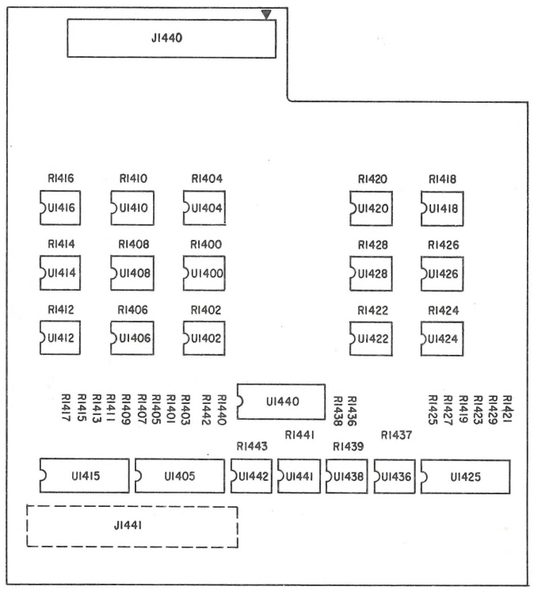

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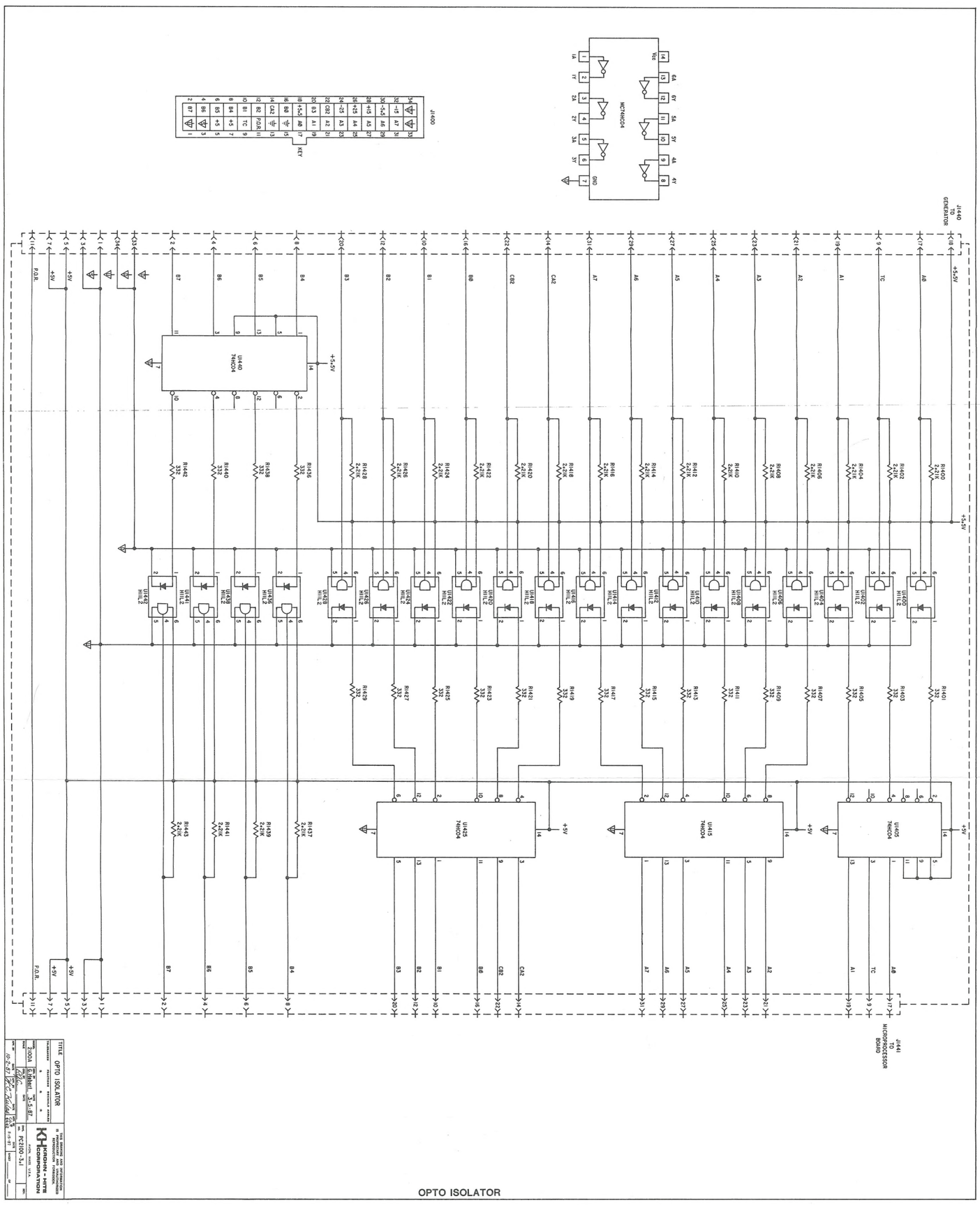
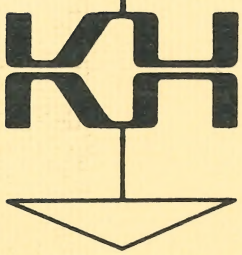


OPTO ISOLATOR



KROHN-HITE
CORPORATION